ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

COMPARISON OF APPROXIMATE AND EXACT METHODS

BY

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A C K N O W L E D G E M E N T

The subject matter and title were suggested by Dr. Jack Nasser, Professor of Civil Engineering, A.U.B. His help, devotion and constructive criticism were indispensable guiding lines all through; from the choice of the subject till the present appearance of my work.

I am also indebted to Dr. Nasser's endeavor during his special visit last September to the I.B.M. Center in Paris from where he brought some important programs among which was the Frame Analysis one.

I also wish to express my thanks to:

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Beirut, Lebanon

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CHAPTER ONE

SCOPE AND OBJECTIVES

This thesis serves a dual goal. The first deals with the study of the influence of wind on high reinforced concrete buildings, and the comparison of two methods of analysis. The first one, the Hardy Cross Method, is considered as an ingenious and convenient method of handling the stress analysis of all types of rigid joint structures subjected to any sort of loading. The other being the Factor Method, is used only for analyzing building frames acted upon by lateral loads.

The Hardy Cross Method gives exact values because it consists in solving the simultaneous equation in the slope-deflection method by successive approximations.

"The Factor Method is the most accurate among the approximate methods. Whereas the Portal and Cantilever Methods depend upon certain stress assumptions that make possible a stress analysis based on the equations of statics, the Factor Method depends on certain assumptions regarding the elastic action of the structure, which makes possible an approximate slope-deflection analysis of the frame. While based upon the slope-deflection method of analysis, it is possible to formulate a relatively simple set of rules by which the method can be applied without knowledge of the elastic principles upon which it is based."(1)

The statements made so far convey that the comparison is one based on competitive exactness of the two different methods. Such a

(1) J.B. Wilbur and C.H. Norris, "Elementary Structural Analysis", p. 280, McGraw-Hill Book Company, New York, 1948.

evaluation in the author's point of view is unfair, because the Founder of the Factor Method does not claim,in any respect, the exactness of his method as compared with the Hardy Cross Method.

The basic concept of this comparison is one regarding the fundamentals of the methods, which could be misleading in the case of the Factor Method while it is not the case with the Hardy Cross Method.

The author ran three sets of calculations by the two methods for the cases mentioned below:

1. A frame with very stiff columns versus concealed beams with an extremely small stiffness.
2. A frame with the same column stiffness in "1", versus drop beam of better stiffness than in "1", but yet with relatively small stiffness as compared to the columns.
3. A frame with columns and beams whose stiffness is of the same order.

In all the three sets of analyses the Factor Method gave values of moments for both the columns and beams which indicated no signs of erroneous results even for the first two critical cases, but failed to do so when checked by the Hardy Cross Method.

I shall go no further regarding the first objective which constitutes the backbone of this thesis, and which was encouraged by Dean John B. Wilbur, former Dean of the School of Engineering, A.U.B., and the founder of the Factor Method.

The second objective of this thesis is a numerical illustration of the analysis carried out in the first part. In order to be practical in this thesis the author ran his analysis on the frames of a twenty story reinforced concrete building with assumed site conditions which were maintained constant throughout the whole thesis.

Finally, it was not my intention to go into metereological or physical description of wind. The only variables being the sections of the members.

CHAPTER TWO

S T U D Y OF W I N D

Wind Loads, General Discussion:

Wind load is one of the most important loads that an engineer has to deal with and is also one that is most difficult to evaluate properly. The magnitude of wind pressure is intimately connected with wind velocity, and (as has been determined by tests of model structures in wind tunnels) with the shape of the structure. The magnitude of wind velocity varies with the geographical location of the structure and the height of the structure. These involved relationships have resulted in a very chaotic situation which is being clarified at the present time. Two solutions to the problem of evaluating wind loads are usually considered: the present solution, as reflected in buildings codes and specifications; and the future solution, as is anticipated in current periodical literature. The fundamental approach, however, is the same, namely, the relationship between velocity and pressure.

Relationship Between Velocity and Pressure:

The derivation of this relationship is, like so much of engineering, due to Sir Issac Newton and is therefore quite frequently referred to as the Newtonian Theory. If a stream of air flows around an object, as shown in Fig. 1 , a pressure is created on the "nose" of the object. The pressure may be found from a consideration of the energy involved.

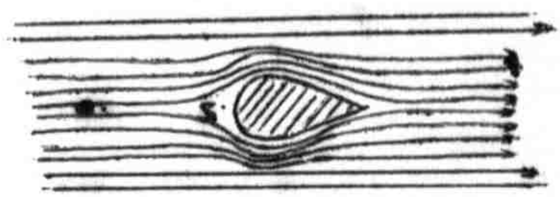

Fig. 1

Energy exists in three forms: Kinetic energy, potential energy, and pressure energy. They are defined as follows:

1. Kinetic Energy: This is the energy which a mass possesses because of its motion; that is,

$$KE = \frac{1}{2} Mv^2 = \frac{Wv^2}{2g}$$

where M = mass

W = weight

g = gravitational constant

v = velocity

2. Potential Energy: This is the energy a mass possesses because of its position above some horizontal datum plane. Therefore

$$Pot. E = WZ$$

where Z = the distance above the datum plane.

3. Pressure Energy: This is the energy that a fluid has because it is under pressure, for example, water in a pipe under pressure has

pressure energy. Hence,

$$\text{Press. E.} = \frac{W \times p}{w}$$

where p = pressure

W = weight the pressure could lift

w = weight per unit volume of the fluid.

Fig. 2 shows fluid in a pipe which has energy of the three types.

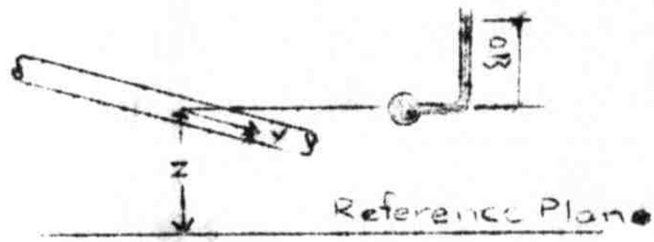

Fig. 2

In any fluid flow the sum of the energies at all points must be constant, as has been stated by Bernoulli, that is

$$\frac{Wv^2}{2g} + WZ + \frac{WP}{w} = \text{constant.}$$

If each term is divided by W, the sum of the resulting three terms is called total load and is designated H. Therefore,

$$H = \frac{V^2}{2g} + Z + \frac{p}{w}$$

The three terms are called velocity head, gravity head, and pressure head respectively. If each term is multiplied by w, then the total energy, E, per unit volume is obtained as

$$E = \frac{wv^2}{2g} + wZ + P$$

The energy per unit volume as given above must remain constant for all points in the fluid.

In any object such as that shown in Fig. 1 there is a point, S, where the air has no velocity. This point is called the stagnation point. Since the energy at points 0 and S must be the same, then

$$p_o + \frac{wvo^2}{2g} = ps$$

The potential energy term does not appear since both points are being considered at the same elevation. It follows that

$$ps - po = \frac{wv_o^2}{2g}$$

The rise in pressure, ps - po, caused by bringing the air to rest, is the impact pressure of the air on the object and will be called q. Therefore,

$$q = \frac{wvo^2}{2g} = \frac{wv^2}{2g}$$

The weight per unit volume of air varies with the temperature and the barometric pressure, and increases with a decrease in temperature. However, for a specific condition both W and g are constants.

Therefore, $q = C_1 V^2$

Tests by Hillman of the action of wind pressure on vertical rigid obstacles resulted in

$$qd = \frac{V^2}{16}$$

where qd = dynamic pressure in Kg/m^2

V = velocity in m/sec.

Early experiments tried to verify the value of q by tests, that is, they tried to prove that

$$p = q$$

where p is the pressure on an object, but they were unsuccessful, until wind tunnels for research into aeronautical problems were devised. Here it was quickly learned, where controlled air flow as possible, that the proper relationship is

$$p = C_2 . q$$

in which C_2 is a coefficient that varies with the size, shape, and position of the object in the air stream. The early experiments did not realize that the object itself had an effect, outside the projected area, on the pressure to which it was subjected.

Tests made by Hillman resulted in

$$p = C_3 \, Kr. \, Ks \, qd$$

where K_s = factor of site

Kr = factor of resonance

C_3 = factor due to taking into account the suction behind the building.

The values of the factors cited above are determined from experiments.

1. Ks

a = protected site = 0.60 - 0.80

b - ordinary site = 1.00

c - exposed site = 1.20 - 1.40

2. Kr

Determined from Fig. 4b, where

$\lambda = \frac{2s}{H}$

H being the height of the structure above ground, and s is the surface area up to mid-height.

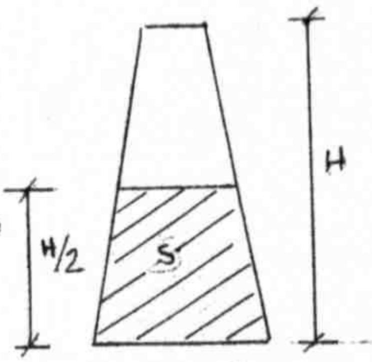

Fig 3

3. C_3 is usually taken as 1.20

Variation of Velocity and Dynamic Pressure with Height:

Wind velocity increases with height because the friction of the air and the earth reduces velocity near the ground. During 1889 extended observations were made from the top of the Eiffel Tower and simultaneously from the meteorological station near the base. The average velocity of the observations at the top (elevation 994 ft) was 15.80 miles per hour and at the base of the station (elevation 69 ft) was 5 miles per hour. On account of the low velocities these figures are of little use to the structural engineer. (For higher velocities the differences were less).

The Stevenson formula so often quoted in textbooks is

$$V = v \left(\frac{H + 72}{h + 72} \right) \quad \text{(English Units)}$$

in which V is the velocity at a height H and v is the velocity at a lesser height h. The observations of Stevenson were made on heights not exceeding 50 ft. and on winds varying from 2 to 44 miles per hour. This is too limited a range for the structural engineer, although Stevenson later wrote that the formula "should be applicable to lofty engineering structures such as lighthouse towers, chimneys, and high-level bridges".

Another formula often quoted is the Archibald formula. Professor Archibald endeavored to determine values for the exponent X in the equation $\frac{V}{v} = \left(\frac{H}{h} \right)^X$

The Archibald formula is often given:

$$\frac{V}{v} = \left(\frac{H}{h} \right)^{\frac{1}{4}}$$

From the standpoint of this thesis the equation presented below is adopted.

$$\frac{qH}{q10} = 2.50 \quad \frac{H + 18}{H + 60}$$ (1)

where qH represents the dyhamic pressure at a height H, where q10 is the pressure at a height of 10 meters.

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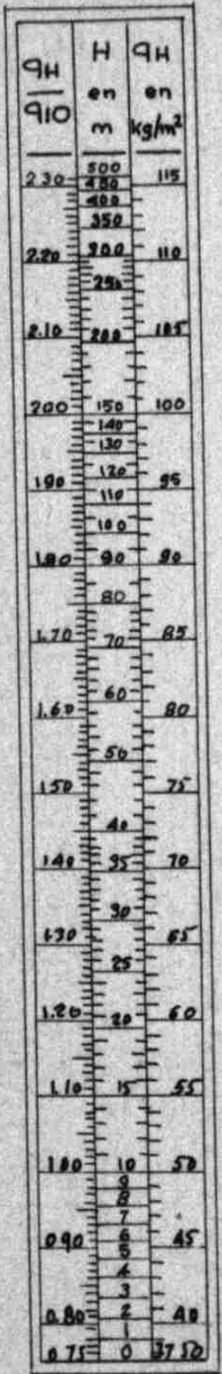
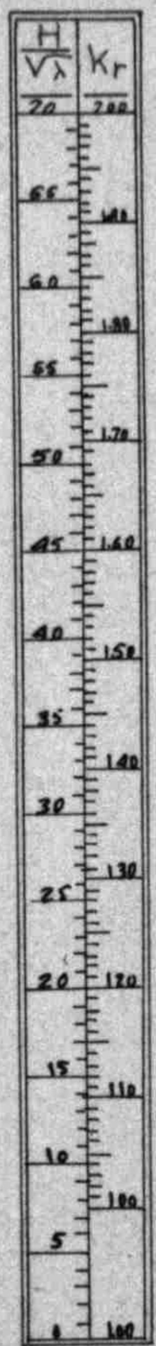
(1) "Regles Definissant Les Effets De La Neige Et Du Vent Sur Les Constructions Applicables Aux Travaux Dependant Du Ministere De La Reconstruction Et De L'Urbanisme," p. 8, Paris, 1947.



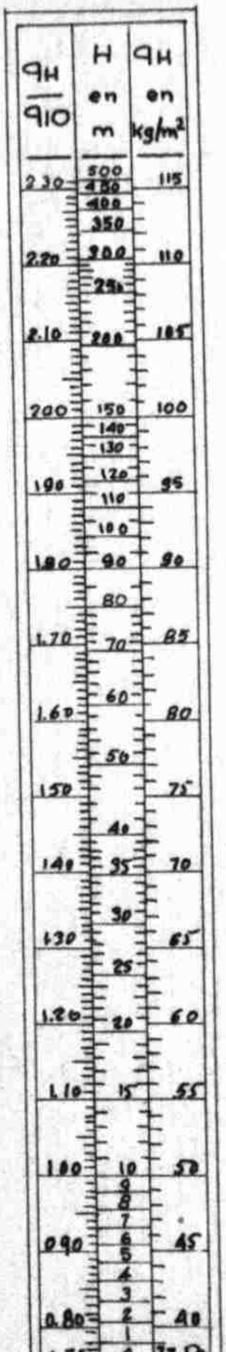
EFFECT OF HEIGHT[1]



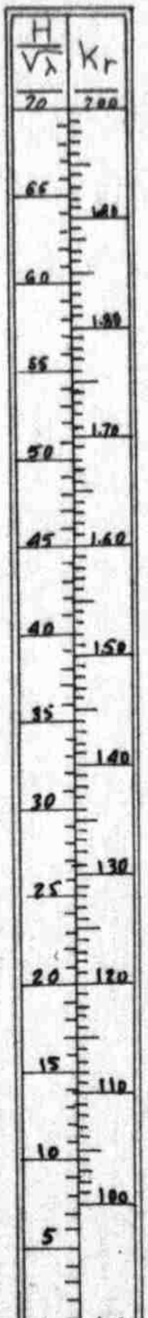
EFFECT OF RESONANCE[1]

Fig.4a, and b.

(1) Ibid, P. 10.



EFFECT OF HEIGHT[1]



EFFECT OF RESONANCE[1]

Fig. 4a, and b.

(1) Ibid, p. 10.

CHAPTER THREE

FACTOR METHOD [1]

This method may be applied by carrying out the following six steps:

1. Compute the girder factor g for each joint. Record at the girder ends at the joint.

$$g = \frac{\Sigma Kc}{\Sigma K}$$

where ΣKc = sum of K values for columns at the joint.

ΣK = sum of K values of all members at the joint.

2. Compute the column factor c for each joint.

$$c = 1 - g$$

Record at the column ends at the joint.

At a fixed base, c = 1.00

3. Every member of the frame has a number appearing at each end. To each number add half the number at the far end of the member.

4. Multiply the sums obtained in step 3 by the K value of the member. Call this number the column moment factor C and the girder moment factor G. The column moment factors C are the approximate relative column-end moment values. Similarly, the girder moment factors G are the

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(1) J.B. Wilbur and C.H. Norris, "Elementary Structural Analysis", p. 280, McGraw-Hill Book Company, New York, 1948.

approximate relative girder-end moment values.

5. The sum of the C values divided by the column height is the relative column shear, and the sum of all the column shears is the story shear. Thus adding the C values for each column gives the relative column shear taken by each column, and the actual shear taken by any column is equal to the story shear multiplied by the sum of the column C values divided by the sum of all of the C values for the story. The column-end moments then follow by simple proportions.

$$M_{C_1} = \frac{C_1}{\Sigma C \text{ for story}} \times Hh$$

All column moments are obtained in a similar fashion.

6. The girder moments are now obtained by statics and simple proportion where necessary.

CHAPTER FOUR

HARDY CROSS METHOD

[1] The Use of Auxiliary Force Systems to Control Translation of the Joints.

The method consists in applying a system of auxiliary forces Fb, Fc, and Fd to prevent any horizontal displacements. This allows the analysis of the structure by the regular moment distribution method. Replace these forces by three different auxiliary force systems, as shown by Figures 1b, c, and d, each of which permits one horizontal displacement. The algebraic relation existing between any single displacement and the force system producing it will be known if it is determined for any assumed value of $\triangle$. Hence, express each auxiliary force system, the shears and the moments which it produces in terms of one displacement Δ .

The equilibrium conditions will result in three equations in terms of the three unknown sidesways, expressed as:

$$Fb_1 + Fb_2 + Fb_3 + Fb = 0$$

$$Fc_1 + Fc_2 + Fc_3 + Fc = 0$$

$$Fd_1 + Fd_2 + fd3 + fd = 0$$

The final moments will be the summation of the corrected values due to the individual action of each displacement.

Analysis of Multistory Frames:

The above method is a powerful and relatively simple tool for determining moments in frames up to three or four floors. This method results in as many simultaneous equations as there are unknown joint translations, i.e.

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[1] L.C. Maugh, "Statically Indeterminate Structures", p. 90, John Wiley & Sons, Inc., New York, 1956.

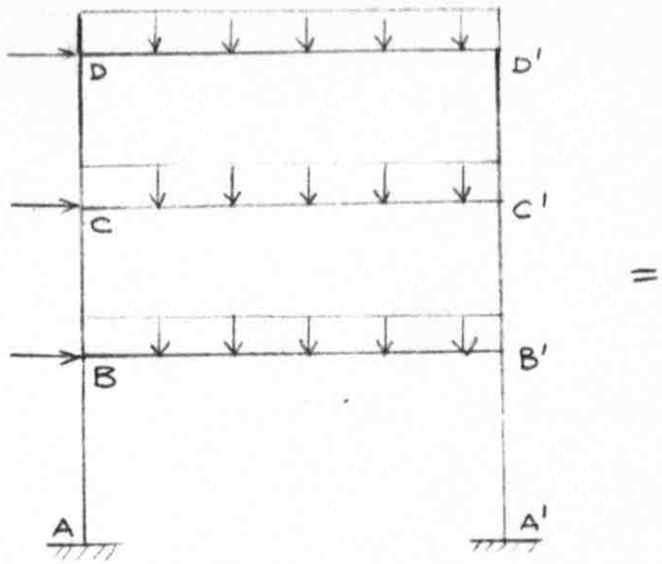

Fig. 1

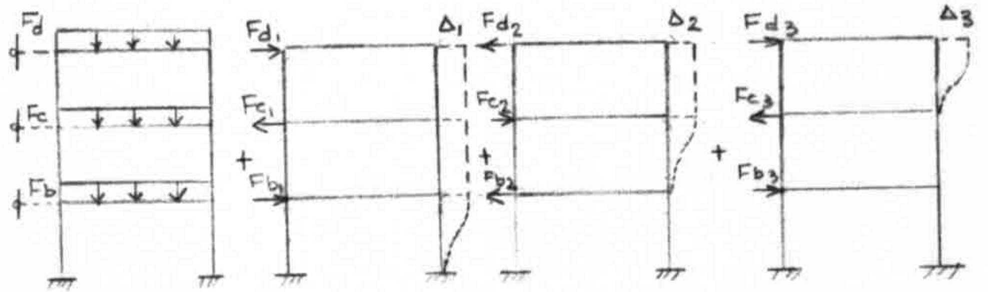

Fig 1a, b, c and d.

twenty equations with twenty unknowns for the case under consideration. Such a set of equations cannot be solved except by the computer. The work and time involved in preparing the equations are subject to many sources of errors. To overcome this difficulty the following method was suggested by Dr. Jack Nasser.

Assume the presence of hinges at mid-height of columns; and analyze the top most three floors. The assumption of hinges influence the lower floors more. So it is suggested to consider the moments of the top floor and the moments in the superior members of the lower floor as correct.

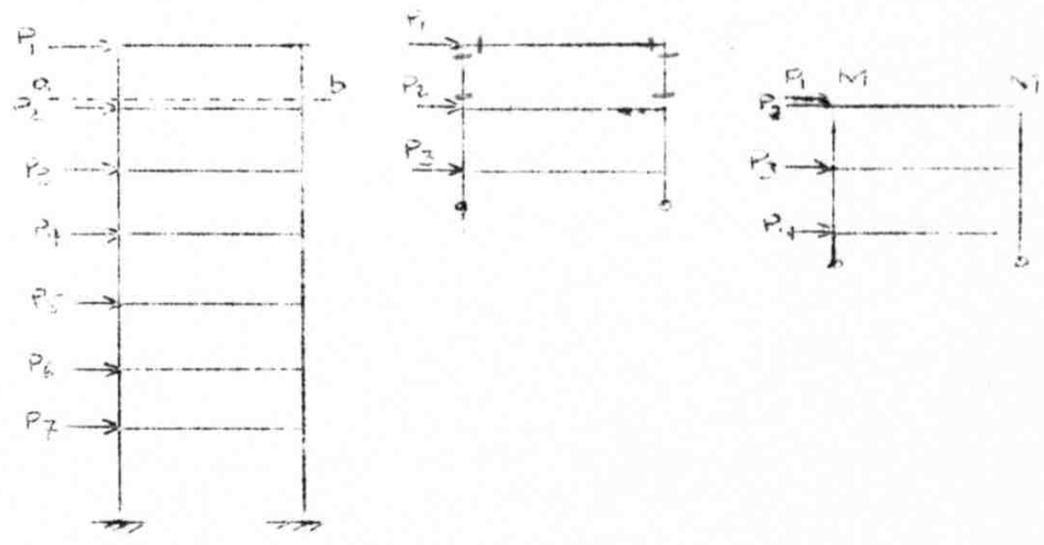

Fig 2a, b, and c

Cut the structure along the line ab, and go one floor lower. This implies the addition of the shear of the cut off floor and the moments of the cut off columns to the joints. This results in a frame subjected to the dual action of lateral forces and moments. The analysis due to the action of moments boils to the same routine as the lateral forces. Much of the computational labor is saved if the total shear is taken when solving the simultaneous equations.

This method was adopted to Case C, while Case A was handled by analyzing the whole structure as a unity. The simultaneous equations were solved on a 1620, I.B.M. Computer.

Signs for Bending Moments:

Signs are one of the most prolific sources of error in analysis.

The convention of signs used in this thesis is as follows:

The internal moments or bending moments calls a moment positive when it produces tension on a designated side of the member. In ordinary design of beams, a bending moment is taken as positive if it produces tension on the bottom of the beam. In columns there is no standard sign for bending moments, we have used below the same convention as for beams when the column is locked at from the right-hand side of the sheet or if the tension is on the inward side of the column if the column is part of a frame.

However, when drawing the moment diagrams the upper side of the beam is considered positive, while the right side of the column is considered positive.

The above statements are interpreted below with the help of the deformation diagrams for a one story frame.

1. Wind From Left

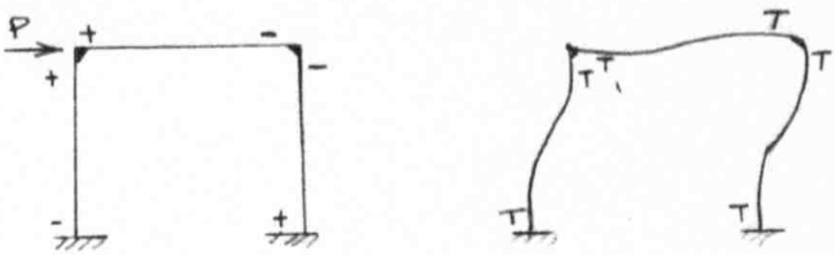

Fig 3a, and b.

2. Wind From Right.

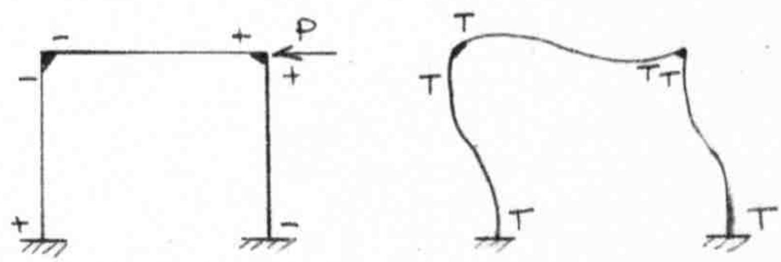

Fig 4a, and b

3. Vertical Loading.

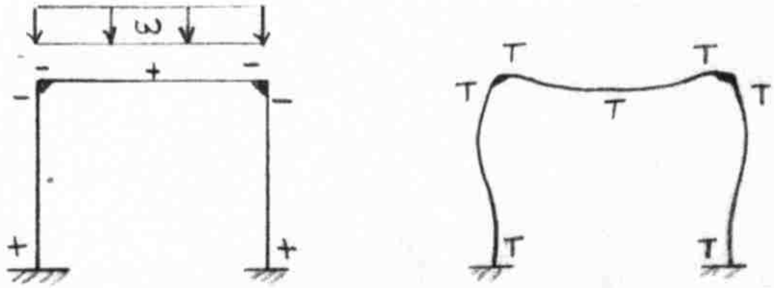

Fig 5a, and b

CHAPTER FIVE

ALLOWANCE FOR SYMMETRY

General:

In most methods of structural analysis it is possible to take advantage of any symmetry in a structure and its loading. Occasionally, however, symmetry is ignored, and much needless effort usually results. Sometimes, after a completely general approach to the analysis of a structure its symmetry is finally used to provide a check on the computations, such a check may, however, be found to apply mostly against the complications arising through neglect of the symmetry. The most evident course is to reduce the computational labour by allowing directly for symmetry, wherever possible.

A structure may be symmetrical, both in its geometry about a point or a "line" support (as, for example, in a continuous beam or a multi-story building frame with an even number of spans or bays). Then, with symmetrical loading there will be no joint rotation one way or the other in the beams passing over or through the central support. In such a case only half of the structure needs to be considered, with the ends of members at the center-line being taken as fixed in position and direction.

Another type of symmetry occurs when a symmetrical structure has its center-line equally between supports (as, for example, in a continuous beam or a multi-story frame with an odd number of spans). Then, with symmetrical loading, the adjacent joints on either side of the center-line, and at the same level, must undergo equal and opposite regular displacements. Clearly only half of the structure need by analyzed if a stiffness modifications can be deduced for the central member. If the stiffness and restraint factors are known for these members when they are considered fixed-ended, the modified stiffness in this case can easily be deduced.

The various cases of symmetrical frames are discussed below:

Hardy Cross Method (1)

1. Symmetrical Structures Symmetrically Loaded

a. Even Number of Span

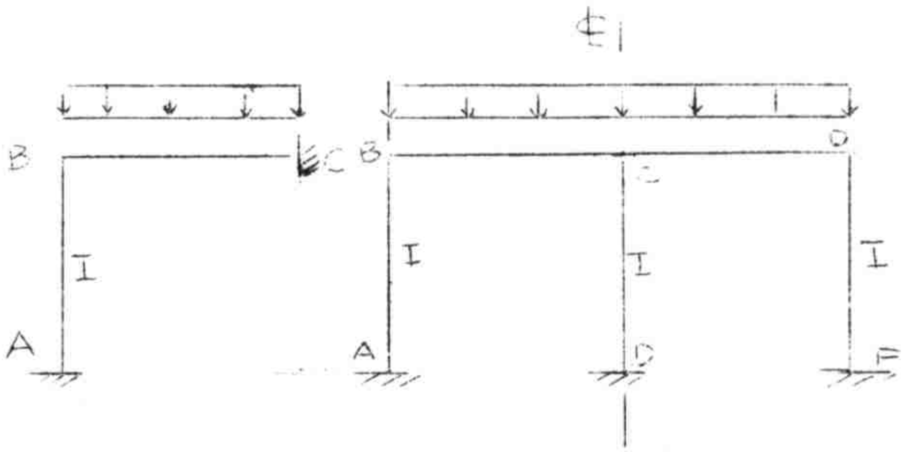

Fig. 1

CD will not move, therefore study ABC without any modifications of the factors.

b. Odd Number of Spans

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(1) The contents of this section have been selected from material developed by Dr. Jack Nasser for the course of Advanced Structural Analysis for graduate students at the American University of Beirut.

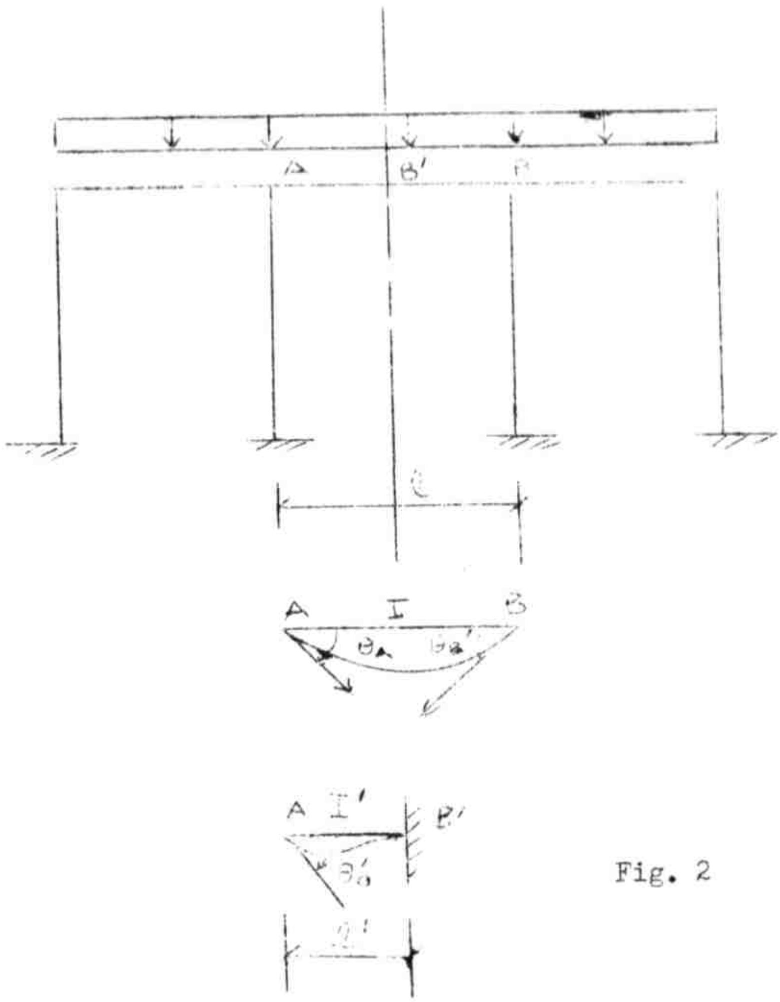

Fig. 2

$\theta a = \theta b$

$\theta' a = \theta a$

$M_{AB} = 2EK_{AB}\ (2\theta_A + \theta B) = 2EK_{AB}\theta_A = 2E\ \frac{I}{l}\ \theta_A$

$M_{AB'} = 2EK_{AB'} \times 2\theta' A = 4E\ \frac{I'}{l'}\ \theta A$

$2E.\ \frac{I}{l}.\ \theta A = 4E\ \frac{I'}{l'}\ \theta A$

$\frac{I}{l} = 2\ \frac{I'}{l'}$

$\frac{I'}{l'} = \frac{1}{2} \times \frac{1}{l}$

$\therefore\ K_{AB'} = \frac{1}{2}\ K_{AB}$

Hence in symmetrical structures symmetrically loaded with an odd number of spans it is allowable to analyze half of the structure provided the central span fixed end moment corresponds to its real stiffness and a factor of stiffness equal to one half of the real stiffness.

2. Symmetrical Structures Non-Symmetrically Loaded

a. Even Number of Spans

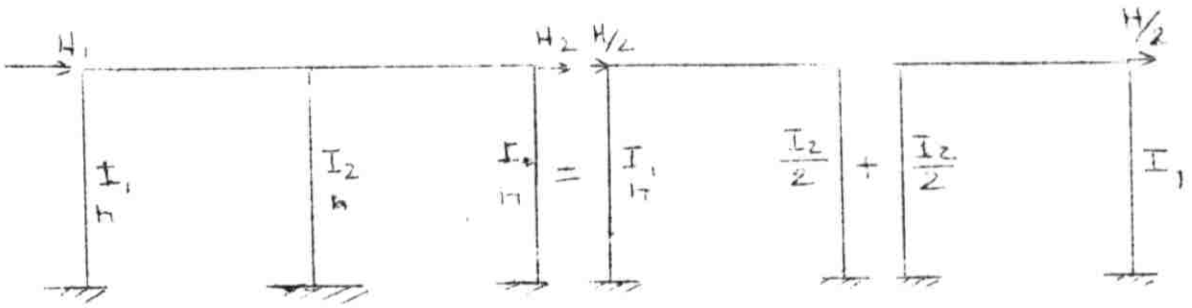

Fig. 3

where $H = H_1 + H_2$

b. Odd Numbers of Spans

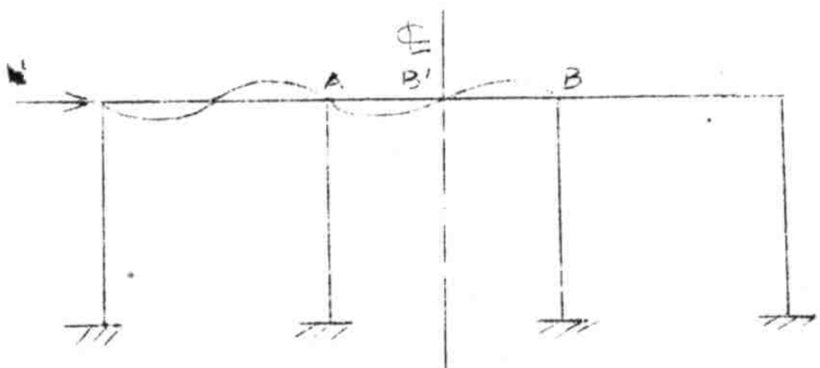

Fig. 4

Because a point of inflection exists at B', MB' = 0

Hence B' acts like a hinge from a deformation point of view.

$K_{AB} = \frac{I}{l}$

$$(K_{AB'})^R = \frac{3}{4}\cdot\frac{I}{\ell/2} = 1.50\ \frac{I}{\ell}$$

Whence analyze half of the structure, supposing a hinge at midpoint by taking a stiffness for AB' equal to three half times AB.

<u>Factor Method</u>:

Because the Factor Method is a relatively short method, no attempts were made in textbooks about the utilization of the factors of symmetry. However, starting from the basic fact that the Factor Method combines both statics and the elastic behavior of members, the author was able to arrive at definite short cuts, which are in one way or another similar to the previous simplifications utilized by the Cross Method.

Symmetrical Structures Non-Symmetrically Loaded

a. Odd Number of Spans

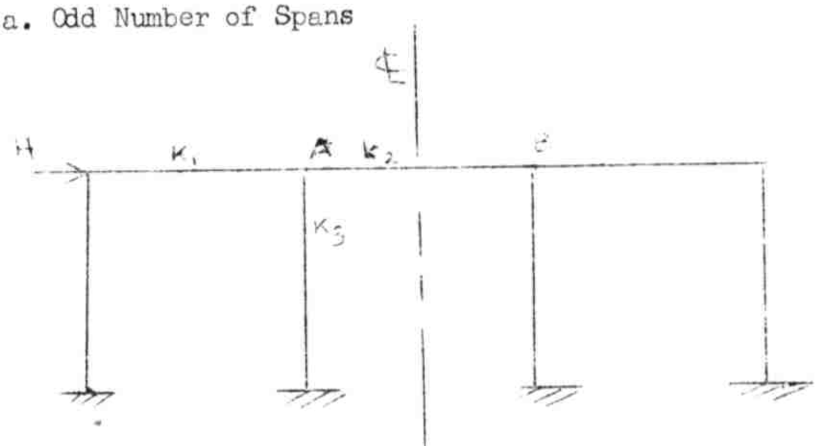

Fig. 5

The g-Factor at joint A is always equal to $\dfrac{K_3}{K_1 + K_2 + K_3}$ irrespective of whether we are analyzing the whole structure or half of it provided that the stiffness of AB is kept the same in both analysis. Hence the c-Factor is kept constant at joint A.

However, when analyzing half the structure we are discarding half the value of the g-Factor coming to A from B and vice versa. Since the g-Factors at A and B are the same, after the c-Factors are calculated take 1.50 times the g-Factor at joint A. The fact that we are analyzing half the structure implies taking half the value of the shear.

Rule:

Analyze half the structure maintaining the same stiffness factor for the central span, provided that the c-Factor is calculated on the basis of the true g-Factor, then a modified g-Factor of three half times the true value is maintained throughout the rest of the calculations.

b. Even Number of Spans

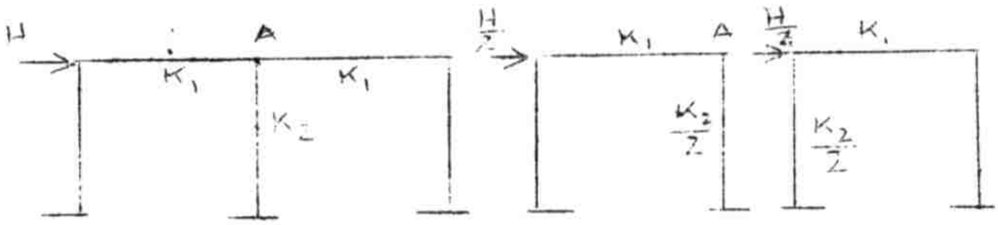

Fig. 6

g-Factor for A when analyzing the whole structure is equal to

$$\frac{K_2}{K_1 + K_1 + K_2} = \frac{K_2}{2K_1 + K_2}$$

g-Factor for A when analyzing half the structure is equal to

$$\frac{K_2/2}{K_1 + \frac{K_2}{2}} = \frac{K_2}{2\left(\frac{2K_1 + K_2}{2}\right)} = \frac{K_2}{2K_1 + K_2}$$

Hence the same rule for the Hardy Cross Method applies in this case.

CHAPTER SIX

SIMULTANEOUS EQUATION SOLUTION BY COMPUTER(1)

Description:

This program generates solutions to a linear system of maximum matrix 39 x 39 with from 1 to 99 vectors. Division feature and indirect addressing are not necessary. The solution is accomplished without matrix inversion by the product matrix method. This method requires only $m^3/2$ multiplications and divisions as opposed to inversion which requires m^3 multiplications and divisions. The typed output of this program is the constant vectors and associated solution vectors.

All input and output is in excess 50 floating point notation.

Card Preparation:

Data input consists of 1 header card, 1 or more matrix cards and 1 or more constant vector cards per constant vector set.

Header Card:

Cols. 1 - 2: $\bar{x}x$ = number of rows = number of columns in the matrix of coefficients.

Cols. 3 - 4: $\bar{x}x$ = number of constant vectors.

Matrix Cards:

The matrix of coefficients by rows in floating point form with high order digits flagged. Utilize as many columns and as many cards as

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(1) I.B.M. - 1620 Manuals.

needed with eight elements per card. A matrix of 6 x 6 will use 4 full cards and 40 columns of a 5th. A matrix of 2 x 2 uses only $\frac{1}{2}$ of one cards. A maximum matrix uses 190 full cards and 10 columns of 191st (39 x 39).

Constant Vector Card(s):

The constant vector in floating point form with high order digits flagged. Utilize as many columns and as many cards as needed with eight elements per card. A matrix of 16 x 16 with 1 constant vector of 6 elements requires 2 cards for constant vector description.

If more than 1 constant vector exists begin a new set of constant vector card(s) for each constant vector.

Example:

$2x + 3y = 7$

$9x - 2y = 4$

Card: 1 $\bar{0}2\bar{0}1$

2 $\bar{5}120000000$ $\bar{5}130000000$ $\bar{5}190000000$ $\bar{5}12000000\bar{0}$

3 $\bar{5}170000000$ $\bar{5}140000000$

Operation:

1. Clear memory
2. Load program deck
3. Program halts after loading

4. Ready data in card-read hopper.

5. Press start.

6. Program solves for all constant vector and halts.

If further systems are to be solved, ready reader with data and press start.

<u>Result</u>:

Constant Vector

$\bar{5}170000000$

$\bar{5}140000000$

Solution of system for above listed vector

$\bar{5}084500000$

$\bar{5}117700000$

CHAPTER SEVEN

DISCUSSION OF RESULTS

The problem of the stresses produced in high buildings by wind has long occupied the attention of engineers in the case of buildings of steel; and the increase in height of buildings built of reinforced concrete has in recent years extended the problem to this field. Anyone who has given any thought to the subject knows that these structures are highly indeterminate. The problem involved in indeterminate structures has been approached by two methods: The Factor which is approximate, and the Hardy Cross which is exact. The problems of what wind pressure should be provided for and of how they would best be provided for are as important and were discussed in Chapter 4 (Appendix) no attempt is made here to comment on this part.

The laws of statics tell us a good deal in these problems, usually they tell us all that we really need to know in order to design the structure safely. In any given story the total shear is the total wind pressure above that story, which is assumed to be known. The sum of all bending moments at the top and at the bottom of all columns is, then, this shear multiplied by the height of the story. We may say, then, that the total moment in the story Hh is distributed in some way to the ends of the columns. The question of distribution of moments to columns calculated by the above method in the case of the Factor Method, and the fixed end moments to all member meeting at a joint of a frame structures in the case of the Hardy Cross Method constitutes the first point to be discussed. Undoubtedly, the Hardy Cross Method is more correct because it distributes the moments at any joint in direct proportion to the stiffness of the members, which is a perfectly true assumption; whereas the Factor Method distributes the moments in a given story according to the column factors which again are functions of the stiffness of the columns of a given story. But the way these factors are computed does not, in my opinion, convey much confidence. However, the Factor Method distributes again the column moments at a joint to the beams according to g-Factors calculated as $\frac{\sum Kc}{\sum K}$ at a joint. This point needs a severe criticism, because it assumes that at any joint of a frame structure subject to wind the sum of column moments is equal to the beam moments. This is a completely valid statement in a perfectly rigid joint. The question here arises about the definition of a rigid joint, which could be stated as that joint whereby the members are connected to each other in a perfect manner through welding or bolts.

What about the definition in reinforced concrete terminology? Such definitions are not usually available in textbooks. From my point of view, a good definition should be based on the relative stiffness of the members meeting at a joint - e.g. "A rigid joint is a joint where the relative ratio of the stiffness of columns to that of beams meeting falls within certain limits". What are these limits? These limits are a function of many factors such as the number of member meeting at a joint, the overall height of the structure, the material used, the cross-sectional area, length of members and may be other factors. However, the establishment of those limits are beyond the scope of this thesis. From the experience of the author throughout this analysis, it is conceived that if the stiffness of the members at a joint fall within the same order, it is quite safe to consider the joint rigid.

Hence a value of unity to the limits explained above permits the use of the Factor Method without leading to erroneous results as explained in the first case considered in this thesis, whereas the Hardy Cross Method is a perfectly true method for any kind of structure irrespective of the values of the limits explained above. This marks the second advantage of the Hardy Cross Method and which I believe, is the most important due to the absence of any restrictions regarding its application.

With this background one will be able to understand the results better. In the first two cases the Factor Method gave erroneous values of moments because the stiffness of the beams was very low as compared to the columns, a case whereby the Factor Method cannot be applied as explained before. Whereas the Hardy Cross Method gave correct answers for the first case with very small values of moments for the beams, which is an indication that the joints are not rigid; a case whereby the application of the Factor Method is prohibitive.

The writer was not encouraged to carry out an exact analysis for the second case on the light of the distribution factors calculated which ranged between 0.02 and 0.05 for the first ten floors, indicating no proper transfer of moments from columns (which are the donors) to the beams. The beams in this case being the recipient will acquire moments in proportion to their distribution factors, thus creating a partial problem which resolves itself in one way or another as an integral part of the first case. In the last case, when abiding by the restriction referred to on page 31 , both methods lead to nearly the same results. This indicates that the Factor Method could be considered dependable for similar cases.

One more point should be discussed in order to be objective in this discussion. The time required to carry out an exact analysis is about ten times as much. In some cases, the need of meeting time schedules may be controlling factor. In other instances, economic considerations may make it desirable to use an approximate method of analysis. It may be less expensive to use more material, as a result of basing design on approximate stresses and on a higher apparent factor of safety with respect to the computed stresses, than to save material by basing design on exact stresses and a lower apparent factor of safety. This attitude may sometimes be properly taken in designing relatively unimportant structures or secondary portions of important structures. The analyst will also be influenced in this connection by his judgment as to magnitude of the errors likely to be introduced by the approximate method he proposes to use. Again, when the design of a statically indeterminate structure is first begun, the areas and moments of inertia of its members are not known. It is therefore necessary to carry out an approximate analysis for stresses in the structure, so as to obtain some idea as to the required sizes of these members. Once these tentative sizes have been assigned, an exact analysis may be carried out.

CHAPTER EIGHT

C O N C L U S I O N S

This investigation was limited to the study of one building. Therefore, only some conclusions can be stipulated about buildings of the same nature. Details may be subject to some revision should more extensive cases be considered. The following conclusions seem to be indicated:

1. The problem of wind stresses in high buildings differ from that of low buildings in the relative stiffness of the beams and columns. In low buildings, the beams are normally stiff and the columns light and flexible, whereas in high buildings for office or resident use, the relative stiffness of the beams is smaller than that of the columns especially in the lower stories.

2. The Hardy Cross Method is an exact method of analysis. Its only disadvantage is the time required for the analysis.

3. The Factor Method applies mainly to low buildings, or else in the preliminary design of high buildings, and could be used for final design purposes, provided the analyst is sure that it will not mislead him as explained in the previous chapter. This method has the advantage of giving quick results.

4. The question of the establishment of the limits regarding the ratio of stiffness of members meeting at a joint is an important problem, because it serves as a guide to the application of the Factor Method which in my line of thinking, is quite a good method provided one knows when and where to apply it.

5. The question of symmetry of structures should be given further attention on the part of engineers because less computational labour is required. The author has the pleasure of being able to introduce some short-cuts regarding the use of symmetry in as far as the Factor Method is concerned.

6. As a result of the stimulus provided by the development of automatic digital computers, spectacular advances have bemn made during the last ten years in the field of structural analysis, both in theory of structural behavior and the techniques of numerical analysis. Analysis of complex structures, that could have been obtained only approximately and at the cost of tremendous computational effort a few years ago, may now be conducted exactly by routine application of standard computer programs.

7. The question of stiffness should be given further consideration on the part of engineers, because the calculation of the inertia of members on the basis of concrete section only is rather a poor assumption.

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pt.2

ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

COMPARISON OF APPROXIMATE AND EXACT METHODS

BY

RIAD M. SHAHIN, B.ENG.

SUBMITTED TO THE SCHOOL OF ENGINEERING, AMERICAN UNIVERSITY OF BEIRUT, IN PARTIAL FULFILMENT OF REQUIREMENTS FOR THE DEGREE OF MASTER OF ENGINEERING WITH MAJOR IN CIVIL ENGINEERING.

ADVISOR: DR. JACK NASSER

BEIRUT, LEBANON

DECEMBER, 1964

TABLE OF CONTENTS

NOTATIONS

Unless otherwise specified, notations are as follows:

A_s = Area of tensile reinforcement.

A_s' = Area of compression reinforcement.

b = Width of rectangular beam and width of T-section beam.

b' = Width of the T-section beam.

d = Depth from centroid of tensile reinforcement to the compression face of the beam.

D = Bar diameter.

E = Modulus of elasticity.

f_c' = Ultimate compression strength of concrete.

f_s = Stress in tensile reinforcement.

I = Moment of Inertia.

kd = Depth from neutral axis to the compression face of the beam.

M_c = Resisting Moment of Concrete

n = Modular ratio.

u = Unit bond stress.

v = Unit shear stress

w = Weight per unit length of the member.

Σo = Perimeter of the bars.

Δ = Deflection.

I = Inferior Member at a joint.

S = Superior Member at a joint.

R = Right Member at a joint.

L = Left Member at a joint.

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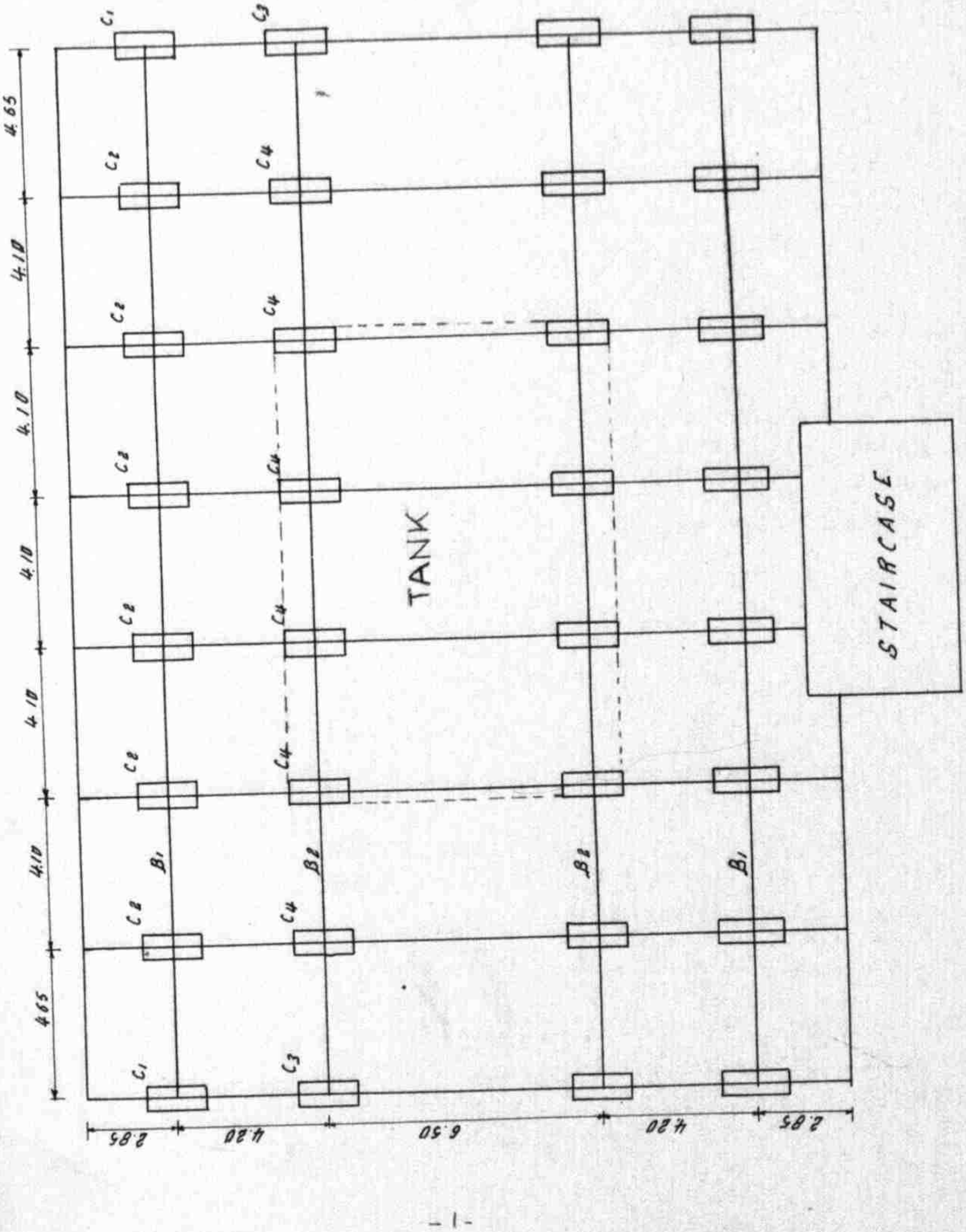

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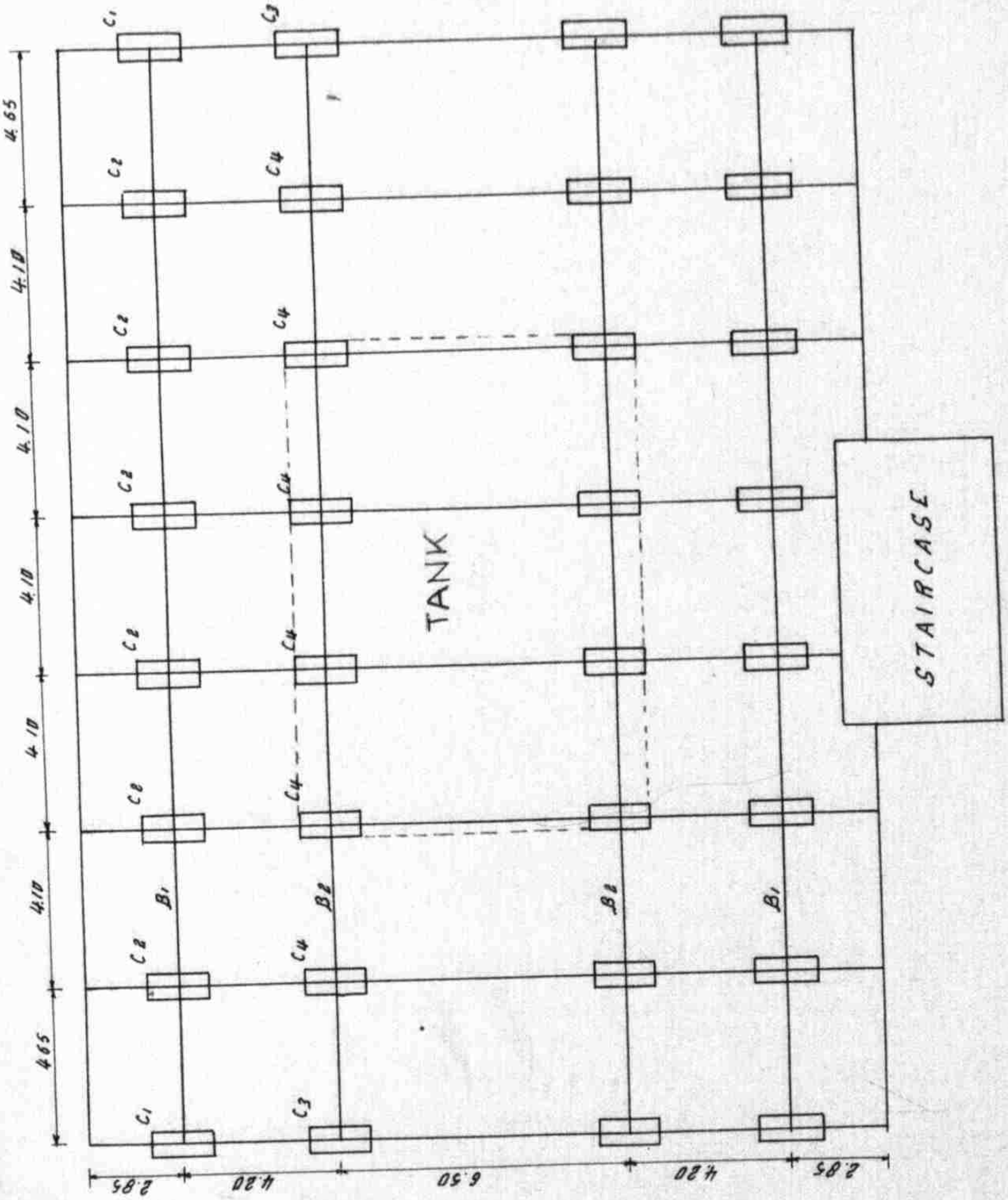
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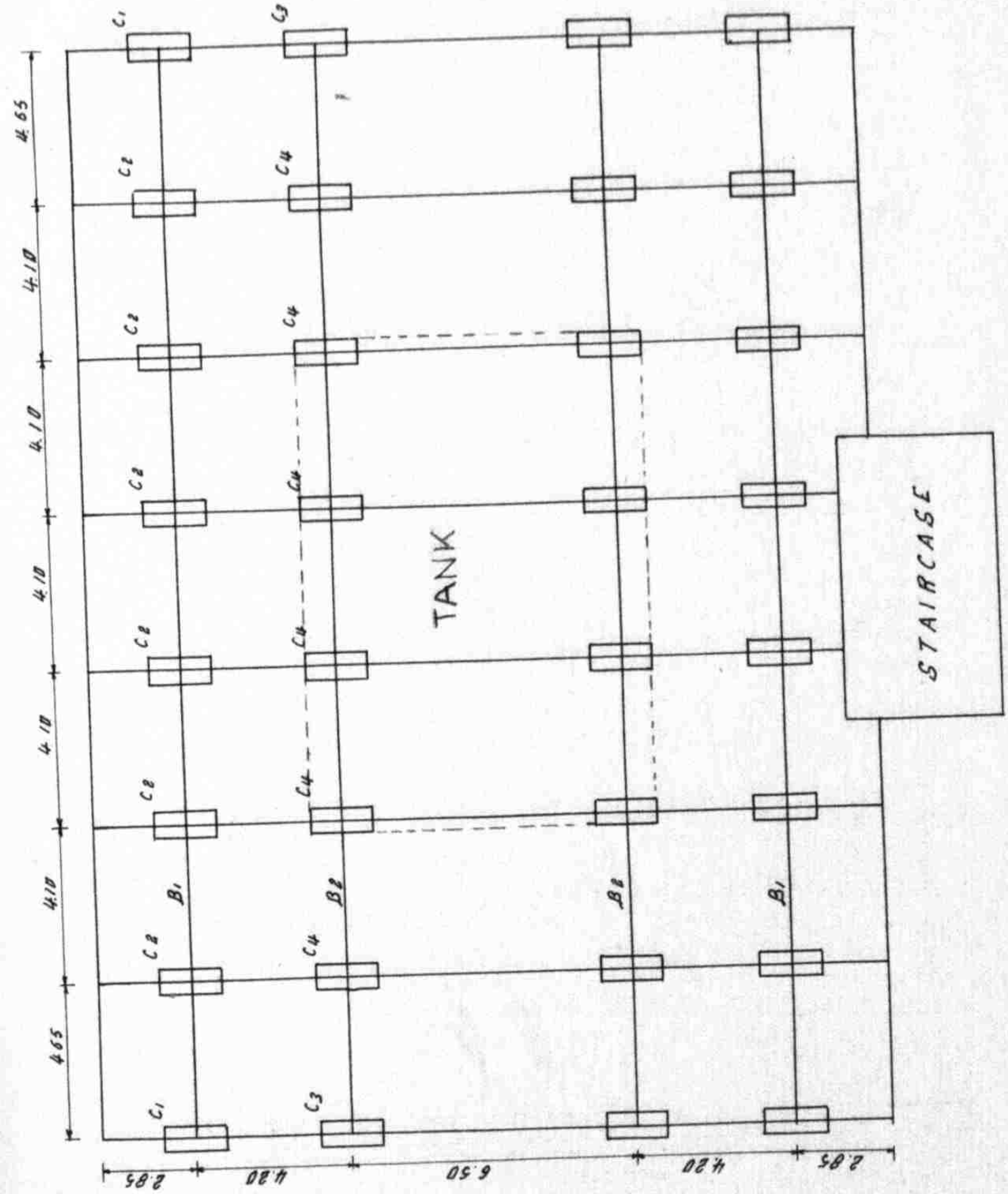
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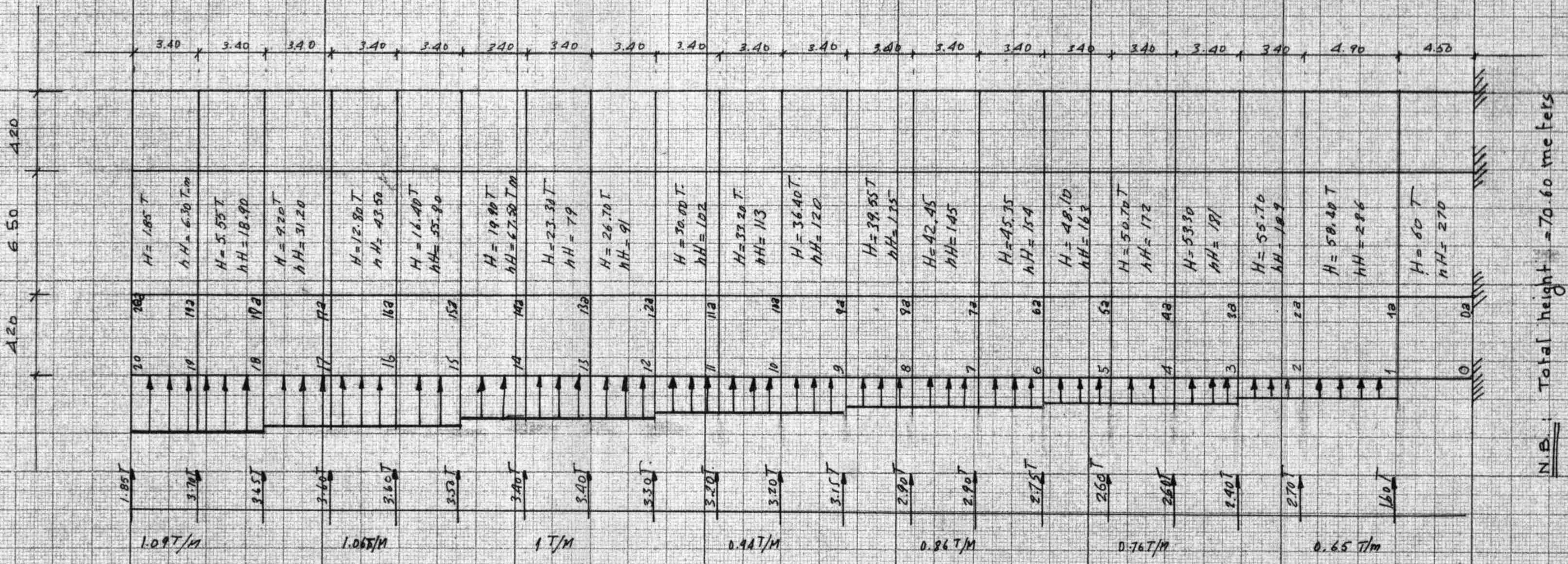

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Comparison of Approximate and Exact Methods

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CHK'D BY : RIAD SHAHIN	
APP'D BY : Dr JACK NASSER	DATE : DECEMBER 1964 — SHEET No 2/

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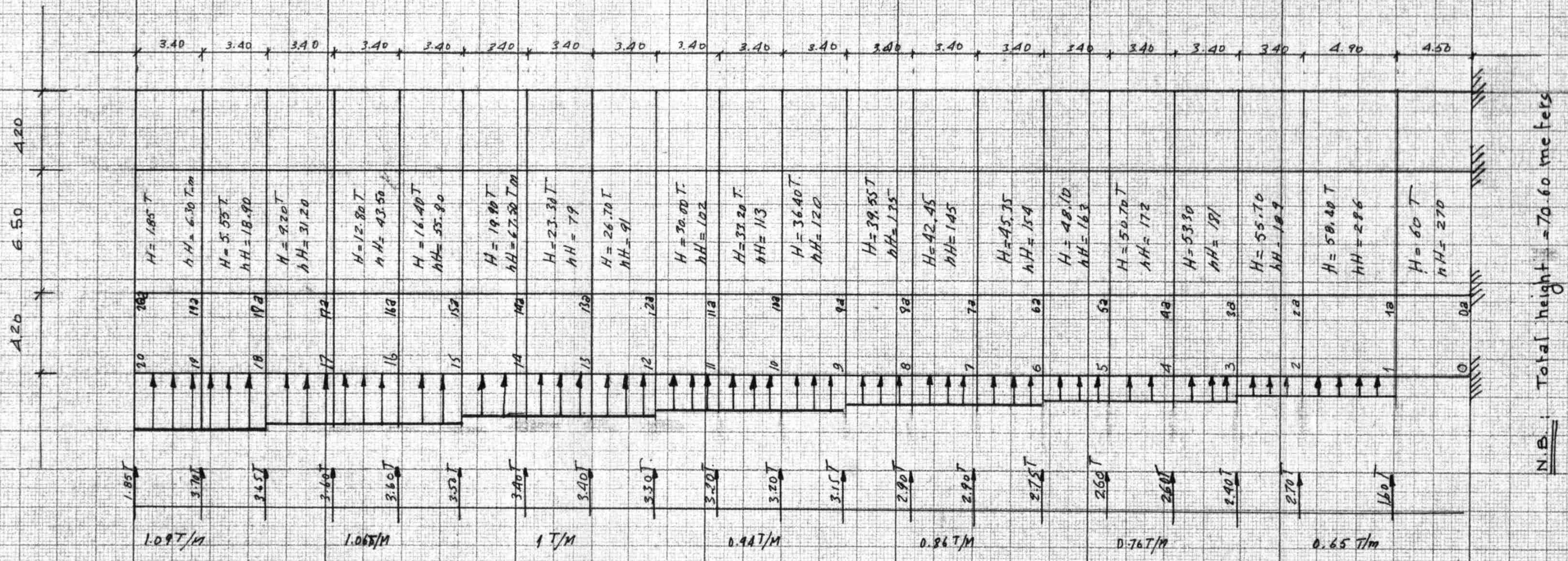

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CHAPTER ONE

WIND CALCULATIONS

Assume on exposed site conditions:

$$q = C_3 \, Kr. \, Ks.qd$$

$$C_3 = 1.25$$

$$Ks = 1.20$$

$$\lambda = \frac{2S}{H} = \frac{2(h/2 \times b)}{H} = b$$

where b is the distance c-c of frames

$$\frac{H}{\sqrt{\lambda}} = \frac{66.10}{\sqrt{\frac{4.65+4.30}{2}}} = 30 \text{ m}$$

$$\therefore Kr = 1.36$$

$$q = 1.25 \times 1.36 \times 1.20 \text{ qd} = 2.00 \text{ qd}$$

Assume a wind velocity of **125** Km/hr.

$$\therefore V = \frac{125 \times 100}{3600} = 34.70 \text{ m/sec.}$$

$$qd = \frac{\overline{34.70}^2}{16} = 75 \text{ Kg/m}^2$$

$$q = 2.00 \times 75 = 150 \text{ Kg/m}^2$$

$$q = 150 \left(\frac{4.65+4.10}{2} \right) = 650 \text{ Kg/m}$$

Height of structure above ground = 3.40x18+4.90 = 66.10 m

Assume that the second and third floors to have $q_1 = 0.65$ T/m, and change the intensity every third floor.

$$q_2 = \left(\frac{H+18}{H+60} \right) \; 2.50 \; w_1 = \left(\frac{H+18}{H+60} \right) 1.63$$

$$= 1.63 \left(\frac{18.50 + 18.00}{18.50+60} \right) = 1.63 \times \frac{36.50}{78.50} = 0.76 \text{ T/m}$$

$$q_3 = 1.63 \left(\frac{28.70 + 18.00}{28.70 + 60.00} \right) = 1.63 \times \frac{46.70}{88.70} = 0.86 \text{ T/m}$$

$$q_4 = 1.63 \left(\frac{38.90 + 18.00}{38.90 + 60.00} \right) = 1.63 \times \frac{56.90}{98.90} = 0.94 \text{ T/m}$$

$$q_5 = 1.63 \left(\frac{49.10 + 18.00}{49.10 + 60.00} \right) = 1.63 \times \frac{67.10}{109.10} = 1.00 \text{ T/m}$$

$$q_6 = 1.63 \left(\frac{59.30 + 18.00}{59.30 + 60.00} \right) = 1.63 \times \frac{77.30}{119.30} = 1.06 \text{ T/m}$$

$$q_7 = 1.63 \left(\frac{66.10 + 18.00}{66.10 + 60.00} \right) = 1.63 \times \frac{84.10}{126.10} = 1.09 \text{ T/m}$$

w (T/m)	0.65	0.76	0.86	0.94	1.00	1.06	1.09
h (m)	8.30	10.20	10.20	10.20	10.20	10.20	6.80
P (T)	5.40	7.80	8.80	9.60	10.20	10.80	7.40

$$\Sigma P = 60.00 \text{ T}$$

The above uniform loads should be changed to a system of concentrated loads acting on the joints

$$P_1 = 0.65 \times \frac{4.90}{2} = 1.60 \text{ T}$$

$$P_2 = 0.65 \times \left(\frac{4.90 + 3.40}{2} \right) = 2.70 \text{ T}$$

$P_3 = (5.40 - 4.30) + 0.76 \times 1.70 = 2.40$ T

$P_4 = P_5 = 0.76 \times 3.40 = 2.60$ T

$P_6 = (7.80 - 6.50) + 0.86 \times 1.70 = 2.75$ T

$P_7 = P_8 = 0.86 \times 3.40 = 2.90$ T

$P_9 = (8.80 - 7.25) + 0.94 \times 1.70 = 3.15$ T

$P_{10} = P_{11} = 1.60 \times 2 = 3.20$ T

$P_{12} = (9.60 - 8.00) + 1 \times 1.70 = 3.30$ T

$P_{13} = P_{14} = 3.40$ T

$P_{15} = (10.20 - 8.50) + 1.06 \times 1.70 = 3.50$ T

$P_{16} = P_{17} = 3.60$ T

$P_{18} = (10.90 - 9.00) + 1.09 \times 1.70 = 3.65$ T

$P_{19} = 1.85 \times 2 = 3.70$ T

$P_{20} = 1.85$ T

CHAPTER TWO

FACTOR METHOD

CASE A

Introduction:

The analysis consists of:

1. Concealed beams of widths which vary every floor from 50 cms. up to 210 cms. Since the stiffness factor is a direct function of d^3, all the beams have very small stiffness factors.

2. Bulky columns of dimensions varying every floor up to 50 x 200 cms., and hence of relatively very high stiffness factors.

This arrangement implies the use of economical percentages of intermediate grade steel for columns.

K Values For Beams

Joint	Dimensions b×d (m×m)	$d^3/12$	I (m^4)	K_{g1} (Absolute)	K_{g1} (Relative)	K_{g2} (Absolute)	K_{g2} (Relative)
20	0.50×0.30	0.00225	0.00113	0.000270	2.70	0.000174	1.74
19	" "	"	"	"	"	"	"
18	" "	"	"	"	"	"	"
17	" "	"	"	"	"	"	"
16.	0.60×0.30	"	0.00135	0.000320	3.20	0.002080	2.08
15	0.70×0.30	"	0.00157	0.000372	3.72	0.000242	2.42
14	0.80×0.30	"	0.00180	0.000430	4.30	0.000278	2.78
13	0.90×0.30	"	0.00202	0.000480	4.80	0.000310	3.10
12	1.00×0.30	"	0.00225	0.000535	5.35	0.000346	3.46
11	1.20×0.30	"	0.00270	0.000642	6.42	0.00415	4.15
10	1.30×0.30	"	0.00293	0.000700	7.00	0.000450	4.50
9	1.40×0.30	"	0.00315	0.000750	7.50	0.000485	4.85
8	1.60×0.30	"	0.00360	0.000856	8.56	0.000550	5.50
7	1.70×0.30	"	0.00372	0.000890	8.90	0.000570	5.70
6	1.70×0.30	"	0.00372	0.000890	8.90	0.000570	5.70
5	1.80×0.30	"	0.00402	0.000970	9.70	0.000625	6.25
4	1.90×0.30	"	0.00430	0.001030	10.30	0.00662	6.62
3	2.00×0.30	"	0.00450	0.001070	10.70	0.000692	6.92
2	2.10×0.30	"	0.00472	0.001130	11.30	0.00073	7.30
1	2.10×0.30	"	0.00472	0.001130	11.30	0.000570	5.70

K Values For Columns

Joint	Dimensions b x d (m x m)	d^3 (m^3)	I (m^4)	K (Absolute)	K Relative
20	0.50 X 0.20	0.008	0.00033	0.000097	0.97
19	0.50 x 0.20	0.008	0.00033	0.000097	0.97
18	0.50 x 0.30	0.027	0.00113	0.000333	3.33
17	0.50 x 0.45	0.092	0.00383	0.001130	11.30
16	0.50 x 0.55	0.166	0.00690	0.002030	20.30
15	0.50 x 065	0.275	0.01160	0.003380	33.80
14	0.50 x 0.75	0.420	0.01750	0.005150	51.50
13	0.50 x 085	0.620	0.02580	0.007600	76.00
12	0.50 x 0.95	0.860	0.03580	0.010500	105.00
11	0.50 x 1.10	1.330	0.05520	0.016200	162.00
10	0.50 x 1.20	1.720	0.07150	0.021000	210.00
9	0.50 x 1.30	2.200	0.09150	0.027000	270.00
8	0.50 x 1.45	3.050	0.1270	0.037300	373.00
7	0.50 x 1.55	3.720	0.15500	0.046000	460.00
6	0.50 x 165	4.500	0.18700	0.055000	550.00
5	0.50 x 1.80	5.800	0.24200	0.071000	710.00
4	0.50 x 2.00	8.000	0.33300	0.098000	980.00
3	0.50 x 2.00	8.000	0.33300	0.098000	980.00
2	0.50 x 2.00	8.000	0.33300	0.068000	680.00
1	0.50 x 200	8.000	0.33300	0.074000	740.00

Beam And Column Factors

Joint	K_c I	K_c S	ΣK_c	ΣK_{g}	ΣK	g-factor $\frac{\Sigma K_c}{\Sigma K}$	c factor (1 - g)
20	0.97	0	0.97	2.70	3.67	0.265	0.735
19	0.97	0.97	3.67	2.70	4.64	0.418	0.582
18	3.33	0.97	4.30	2.70	7.00	0.615	0.385
17	11.30	3.33	14.63	2.70	17.33	0.855	0.145
16	20.30	11.30	31.60	3.20	34.80	0.905	0.095
15	33.80	20.30	54.10	3.72	57.82	0.935	0.065
14	51.50	33.80	85.30	4.30	89.60	0.950	0.050
13	76.00	51.50	127.50	4.80	132.30	0.960	0.040
12	105.00	76.00	181.00	5.35	186.35	0.970	0.030
11	162.00	105.00	267.00	6.42	273.42	0.972	0.028
10	210.00	162.00	372.00	7.00	379.00	0.980	0.020
9	270.00	210.00	480.00	7.50	489.50	0.984	0.010
8	373.00	270.00	643.00	8.56	651.56	0.986	0.014
7	460.00	373.00	833.00	8.90	841.90	0.988	0.012
6	550.00	460.00	1010.00	8.90	1018.90	0.990	0.010
5	710.00	550.00	1260.00	9.70	1269.70	0.992	0.008
4	980.00	710.00	1690.00	10.30	1700.30	0.992	0.008
3	980.00	980.00	1960.00	10.70	1970.70	0.992	0.008
2	680.00	980.00	1660.00	11.30	1671.30	0.992	0.008
1	740.00	680.00	1420.00	11.30	1431.30	0.992	0.008

Joint (a)	Dimensions b x d (m x m)	d^3 (m^3)	I. (m^4)	K Absolute	K Relative
20	0.50 x 0.20	0.0080	0.00033	0.000097	0.97
19	0.50 x 0.25	0.0157	0.00065	0.000192	1.92
18	0.50 x 0.35	0.0430	0.00179	0.005250	5.25
17	0.50 x 0.45	0.0920	0.00383	0.001130	11.30
16	0.50 x 0.55	0.1660	0.00690	0.002030	20.30
15	0.50 x 0.65	0.2750	0.00115	0.0033800	33.80
14	0.50 x 0.80	0.5100	0.02130	0.006300	63.00
13	0.50 x 0.90	0.7300	0.03030	0.008900	89.00
12	0.50 x 1.00	1.0000	0.04200	0.012300	123.00
11	0.50 x 1.10	1.3300	0.05500	0.016200	162.00
10	0.50 x 1.25	1.9500	0.08100	0.023800	238.00
9	0.50 x 1.35	2.4300	0.10100	0.029800	298.00
8	0.50 x 1.50	3.3500	0.14000	0.041200	412.00
7	0.50 x 1.60	4.1000	0.17000	0.050000	500.00
6	0.50 x 1.70	4.9000	0.20300	0.060000	600.00
5	0.50 x 1.85	6.3000	0.26200	0.077000	770.00
4	0.50 x 2.00	8.0000	0.33300	0.098000	980.00
3	0.50 x 2.00	8.0000	0.33300	0.098000	980.00
2	0.50 x 2.00	8.0000	0.33300	0.068000	680.00
1	0.50 x 2.00	8.0000	0.33300	0.07400	074.00

Joint #	K_g		ΣK_g	ΣK_c	ΣK	g-Factor $\frac{\Sigma K_c}{\Sigma K}$	c-Factor (1-g)
	K_{g1}	K_{g2}					
20	2.70	1.74	4.44	0.97	5.41	0.179	0.821
19	"	"	"	2.89	7.33	0.394	0.606
18	"	"	"	7.17	11.61	0.615	0.385
17	"	"	"	16.55	20.90	0.790	0.210
16	3.20	2.08	5.28	31.60	36.88	0.856	0.144
15	3.72	2.42	6.14	54.10	60.24	0.900	0.100
14	4.30	2.78	7.08	96.80	103.88	0.930	0.070
13	4.80	3.10	7.90	152.00	159.90	0.950	0.050
12	5.35	3.46	8.81	212.00	220.81	0.960	0.040
11	6.42	4.15	10.57	285.00	295.57	0.964	0.036
10	7.00	4.50	11.50	400.00	411.50	0.972	0.028
9	7.50	4.85	12.35	536.00	548.35	0.980	0.020
8	8.56	5.50	14.06	710.00	724.06	0.982	0.018
7	8.90	5.70	14.60	912.00	926.60	0.984	0.016
6	8.90	5.70	14.60	1100.00	1124.60	0.988	0.012
5	9.70	5.70	15.40	1370.00	1385.95	0.990	0.010
4	10.30	6.62	16.92	1750.00	1766.92	0.990	0.010
3	10.70	6.92	17.62	1960.00	1977.62	"	"
2	11.30	7.30	18.60	1660.00	1678.60	"	"
1	11.30	7.30	18.60	1420.00	1438.60	"	"

A Factors

$$A_{20} = \frac{6.30}{2(1.090 + 0.985 + 0.995 + 0.920)} = \frac{3.15}{3.99} = 0.786$$

$$A_{19} = \frac{18.90}{2(1.530 + 0.746 + 1.320 + 0.655)} = \frac{9.45}{4.251} = 2.22$$

$$A_{18} = \frac{31.20}{2(2.570 + 1.53 + 2.12 + 2.210)} = \frac{15.60}{8.43} = 1.83$$

$$A_{17} = \frac{43.50}{2(2.82 + 3.25 + 1.90 + 2.18)} = \frac{21.75}{10.15} = 2.23$$

$$A_{16} = \frac{55.80}{2(3.50 + 3.95 + 2.23 + 2.60)} = \frac{27.90}{12.28} = 2.27$$

$$A_{15} = \frac{67.50}{2(4.06 + 4.56 + 2.81 + 3.05)} = \frac{33.75}{14.48} = 2.33$$

$$A_{14} = \frac{79}{2(5.35 + 6.00 + 3.35 + 3.60)} = \frac{39.50}{18.30} = 2.17$$

$$A_{13} = \frac{91}{2(5.80 + 6.23 + 3.80 + 4.18)} = \frac{45.50}{20.01} = 22.75$$

$$A_{12} = \frac{102}{2(6.90 + 7.13 + 4.52 + 4.62)} = \frac{51}{23.17} = 2.20$$

$$A_{11} = \frac{113}{2(7.43 + 8.10 + 5.50 + 6.15)} = \frac{56.50}{27.18} = 2.08$$

$$A_{10} \quad \frac{120}{2(8.12 + 9.05 + 6.30 + 6.30)} = \frac{60}{29.23} = 2.05$$

$$A_{9} \quad \frac{135}{2(8.35 + 8.65 + 5.92 + 6.20)} = \frac{67.50}{29.12} = 2.32$$

$$A_{8} \quad \frac{145}{2(10.30 + 10.70 + 7.10 + 7.45)} = \frac{72.50}{33.55} = 2.04$$

$$A_{7} \quad \frac{154}{2(10 + 10.70 + 7.10 + 7.45)} = \frac{77}{35.15} = 2.13$$

$$A_{6} \quad \frac{163}{2(9.60 + 10.20 + 6.60 + 7.70)} = \frac{81.50}{34.10} = 2.39$$

$$A_{5} \quad \frac{172.00}{2(11.50 + 11.50 + 8.52 + 8.52)} = \frac{86}{40.04} = 2.15$$

$$A_{4} \quad \frac{181.00}{2(14.70 + 14.70 + 11.70 + 11.70)} = \frac{90.50}{52.80} = 1.72$$

$$A_{3} \quad \frac{189.00}{2(14.70 + 14.70 + 11.70 + 11.70)} = \frac{94.50}{52.80} = 1.79$$

$$A_{2} \quad \frac{286.00}{2(10.20 + 8.15 + 8.15 + 8.15)} = \frac{143.00}{36.70} = 3.90$$

$$A_{1} \quad \frac{270.00}{2(741 + 377 + 740 + 375)} = \frac{135.00}{2233} = 0.0603$$

B Factors

$$B_{20a} = \frac{0.856}{0.84 + 0.47} = \frac{0.856}{0.131} = 0.653$$

$$B_{19a} = \frac{0.773 + 3.370}{1.63 + 1.03} = \frac{4.143}{2.66} = 1.56$$

$$B_{18a} = \frac{2.92 + 4.70}{2.50 + 1.60} = \frac{7.62}{4.10} = 1.86$$

$$B_{17a} = \frac{7.25 + 3.87}{3.28 + 2.23} = \frac{11.12}{5.51} = 2.02$$

$$B_{16a} = \frac{6.30 + 8.95}{4.21 + 2.68} = \frac{15.25}{6.89} = 2.22$$

$$B_{15a} = \frac{10.60 + 7.95}{5.10 + 3.27} = \frac{18.55}{8.37} = 2.22$$

$$B_{14a} = \frac{13.00 + 9.50}{6.03 + 3.87} = \frac{22.50}{9.90} = 2.27$$

$$B_{13a} = \frac{14.20 + 11.50}{6.85 + 4.12} = \frac{25.70}{10.97} = 2.33$$

$$B_{12a} = \frac{15.70 + 13.20}{7.71 + 5.00} = \frac{28.90}{12.71} = 2.28$$

$$B_{11a} = \frac{16.90 + 15.20}{9.32 + 6.00} = \frac{32.10}{15.32} = 2.09$$

$$B_{10a} = \frac{18.50 + 15.50}{10.25 + 6.55} = \frac{34.00}{16.80} = 2.02$$

$$B_{9a} = \frac{16.70 + 20.20}{10.30 + 6.60} = \frac{36.90}{16.90} = 2.18$$

$$B_{8a} = \frac{19.40 + 21.80}{10.30 + 6.60} = \frac{41.20}{16.90} = 2.43$$

$$B_{7a} = \frac{21.00 + 23.50}{13.00 + 8.40} = \frac{44.50}{21.50} = 2.07$$

$$B_{6a} = \frac{21.30 + 24.30}{13.10 + 8.40} = \frac{47.80}{23.70} = 2.12$$

$$B_{5a} = \frac{23.00 + 24.80}{14.40 + 9.30} = \frac{47.80}{23.70} = 2.02$$

$$B_{4a} = \frac{24.80 + 25.20}{15.30 + 9.85} = \frac{50.00}{25.15} = 1.99$$

$$B_{3a} = \frac{25.20 + 26.30}{15.90 + 10.30} = \frac{51.50}{26.20} = 1.97$$

$$B_{2a} = \frac{26.30 + 39.70}{16.80 + 10.85} = \frac{66.00}{27.65} = 2.38$$

$$B_{1a} = \frac{39.70 + 22.70}{16.80 + 10.85} = \frac{62.40}{27.65} = 2.26$$

K = 1.74 · K = 1.74 · K = 1.74 · K = 1.74 · K = 2.01 · K = 2.42 · K = 2.78 · K = 3.10 · K = 3.46 · K = 4.15 · K = 4.50 · K = 4.85 · K = 5.50

0.773 = M
0.995 = 0.97 x 1.017
0.411
0.606
K = 0.97

0.821
0.303
1.124 x 0.97 = 1.09
M = 0.856

0.550 = M
0.84 = 2.70 x 0.312
0.133
0.179
K = 2.70

2.53 = M
1.63 = 2.70 x 0.603
K = 2.70

2.92 = M
1.32 = 1.92 x 0.688
0.303
0.385
K = 1.92

0.606
0.193
0.799 x 1.92 = 1.53
M = 3.37

4.65 = M
2.50 = 2.70 x 0.923
K = 2.70

3.87 = M
2.12 = 5.25 x 0.403
0.173
0.210
K = 3.33

0.385
0.105
0.490 x 5.25 = 3.57
M = 4.70

6.62 = M
3.28 = 2.70 x 1.218
K = 2.70

6.30 = M
2.82 = 11.30 x 0.249
0.105
0.144
K = 11.30

0.210
0.077
0.281 x 11.30 = 3.25

9.30 = M
4.21 = 3.20 x 1.309
K = 3.20

7.95 = M
3.50 = 20.30 x 0.172
0.072
0.100
K = 20.30

0.144
0.050
0.194 x 20.30 = 3.95
M = 8.95

11.30 = M
5.10 = 3.72 x 1.367
K = 3.72

9.50 = M
4.06 = 33.80 x 0.120
0.050
0.070
K = 33.80

0.100
0.035
0.135 x 33.80 = 4.56
M = 10.60

13.70 = M
6.03 = 4.30 x 1.405

11.50 = M
5.35 = 63 x 0.085
0.035
0.050
K = 63

0.070
0.025
0.095 x 63 = 6.00
M = 13

16 = M
6.85 = 4.8 x 1.430
K = 4.80

13.20 = M
5.8 = 89 x 0.065
0.025
0.040
K = 89

0.050
0.020
0.070 x 89 = 6.23
M = 14.20

17.50 = M
7.71 = 5.35 x 1.446
K = 5.35

15.20 = M
6.90 = 123 x 0.056
0.020
0.036
K = 123

0.040
0.018
0.058 x 123 = 7.13
M = 15.70

19.50 = M
9.32 = 6.42 x 1.450
K = 6.42

15.50 = M
7.93 = 162 x 0.046
0.018
0.028
K = 162

0.036
0.014
0.050 x 162 = 8.10
M = 16.40

20.70 = M
10.25 = 7 x 1.462
K = 7.00

16.70 = M
8.12 = 238 x 0.030
0.014
0.020
K = 238

0.028
0.010
0.038 x 238 = 9.05
M = 18.50

22.50 = M
10.30 = 7.50 x 1.472
K = 7.50

19.40 = M
8.85 = 298 x 0.028
0.010
0.018
K = 298

0.020
0.009
0.029 x 298 = 8.65
M = 20.20

25 = M
12.60 = 8.52 x 1.475
K = 8.52

0.018
0.008
0.026 x

M = 0.78 · M = 2.372 · M = 4.24 · M = 6.92 · M = 10.15 · M = 12.17 · M = 14.31 · M = 16.64 · M = 19.75 · M = 22.75 · M = 24.40 · M = 27.30 · M = 28.90

0.722 = M
0.92 = 0.97 x 0.950
0.368
0.582
K = 0.97

0.795
0.291
1.026 (0.97) = 0.995
M = 0.780

1.44 = M
0.655 = 0.97 x 0.676
0.291
0.285
K = 0.97

0.582
0.193
0.775 (0.97) = 0.746
M = 1.65

2.07 = M
1.13 = 3.33 x 0.338
0.193
0.145
K = 3.33

0.385
0.073
0.458 x 3.33 = 1.53
M = 2.80

4.25 = M
1.90 = 11.30 x 0.168
0.073
0.095
K = 11.30

0.145
0.048
0.193 x 11.30 = 2.18
M = 4.85

5.05 = M
2.23 = 20.30 x 0.113
0.048
0.065
K = 20.30

0.095
0.033
0.128 x 20.30 = 2.60
M = 5.90

6.55 = M
2.81 = 33.80 x 0.083
0.033
0.050
K = 33.80

0.065
0.025
0.090 x 33.80 = 3.05
M = 7.12

7.22 = M
3.35 = 51.50 x 0.065
0.025
0.040
K = 51.50

0.050
0.020
0.070 x 51.50 = 3.60
M = 7.76

8.65 = M
3.80 = 76 x 0.050
0.020
0.030
K = 76.00

0.040
0.015
0.055 x 76 = 4.18
M = 9.42

9.95 = M
4.52 = 105 x 0.043
0.015
0.028
K = 105

0.030
0.014
0.044 x 105 = 4.62
M = 10.10

11.50 = M
5.50 = 162 x 0.034
0.014
0.020
K = 162

0.028
0.010
0.038 x 162 = 6.5
M = 12.80

12.90 = M
6.30 = 210 x 0.030
0.010
0.020
K = 210

0.020
0.010
0.030 x 210 = 6.30
M = 12.90

13.70 = M
5.92 = 270 x 0.022
0.008
0.014
K = 270

0.016
0.007
0.023 x 270 = 6.20
M = 14.90

0.014
0.006
0.020

1/2

2/2

ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING	
Comparison of Approximate and Exact Methods	
COMPUTER: RIAD SHAHIN	FACTOR METHOD
CHK'D BY: RIAD SHAHIN	
APP'D BY: Dr. JACK NASSER	DATE: DECEMBER 1964 — SHEET No 14/

CASE B

Introduction:

The analysis **consists** of:

1. Same column dimensions as in previous case.

2. Drop beams of constant widths of 30 cms., and varying depths every fourth floor as such 50, 60, 70, 80, and 90 cms.

The stiffness of beams is about four times as much as the previous case.

K Values For Beams

Joint	Dimensions b x d (m x m)	d^3 (m^3)	b/12 (m)	I (m^4)	K_{g1} (Absolute)	K_{g2} (Absolute)	K_{g1} (Relative)	K_{g2} (Relative)
20-17	030 x 0.50	0.125	0.025	0.00312	0.000.74	0.00048	7.40	4.80
16-13	030 x 060	0.216	0.025	0.00540	0.00128	0.00083	12.80	8.30
12-9	030 x 0.70	0.343	0.025	0.00855	0.00203	0.00131	20.30	13.10
8-5	0.30x0.80	0.512	0.025	0.01280	0.00305	0.00196	30.50	19.60
4-1	0.30x 0.90	0.729	0.025	0.0182	0.00432	0.00280	43.20	28.00

Beam And Column Factors

Joint	ΣK_c	K_{g1}	ΣK	g Factor $\frac{\Sigma K_c}{\Sigma K}$	c Factor $(1-g)$
20	0.97	7.40	8.37	0.116	0.884
19	3.67	"	9.34	0.206	0.794
18	4.30	"	11.70	0.366	0.634
17	14.63	"	21.93	0.662	0.338
16	31.60	12.80	44.30	0.710	0.290
15	54.10	"	66.90	0.810	0.190
14	85.30	"	98.10	0.870	0.130
13	127.50	"	139.30	0.910	0.090
12	181.00	20.30	200.30	0.900	0.100
11	267.00	"	287.30	0.930	0.070
10	372.00	"	392.30	0.950	0.050
9	480.00	"	496.30	0.960	0.040
8	643.00	30.50	669.50	0.940	0.060
7	833.00	"	863.50	0.966	0.034
6	1010.00	"	1040.50	0.970	0.030
5	1260.00	"	1280.50	0.974	0.026
4	1690.00	43.20	1723.20	0.960	0.040
3	1960.00	"	2003.20	0.980	0.020
2	1660.00	"	1703.20	0.974	0.026
1	1420.00	"	1463.20	0.970	0.030

A Factors

$$A_{20} = \frac{3.15}{1.23 + 1.29 + 1.19 + 1.24} = \frac{3.15}{4.95} = 0.636$$

$$A_{19} = \frac{9.45}{1.98 + 2.15 + 1.00 + 1.07} = \frac{9.45}{6.20} = 1.53$$

$$A_{18} = \frac{15.60}{3.85 + 4.40 + 2.18 + 2.67} = \frac{15.60}{13.10} = 1.19$$

$$A_{17} = \frac{21.75}{6.88 + 6.92 + 5.13 + 5.40} = \frac{21.75}{24.27} = 0.895$$

$$A_{16} = \frac{27.90}{9.75 + 11.00 + 6.80 + 7.80} = \frac{27.90}{35.35} = 0.79$$

$$A_{15} = \frac{33.75}{10.80 + 12.50 + 7.60 + 8.60} = \frac{33.75}{39.50} = 0.854$$

$$A_{14} = \frac{39.50}{13.20 + 15.10 + .800 + 9.00} = \frac{39.50}{45.30} = 0.870$$

$$A_{13} = \frac{45.50}{17.60 + 16.70 + 10.90 + 10.50} = \frac{45.50}{55.70} = 0.817$$

$$A_{12} = \frac{51}{21.80 + 23.80 + 12.60 + 14.20} = \frac{51}{72.40} = 0.702$$

$$A_{11} = \frac{56.50}{21.80 + 24.80 + 13.70 + 1530} = \frac{56.50}{75.60} = 0.748$$

$$A_{10} = \frac{60}{23.80 + 26.20 + 13.60 + 14.70} = \frac{60}{78.30} = 0.762$$

$$A_{9} = \frac{67.50}{28.70 + 27.60 + 21.20 + 18.50} = \frac{67.50}{96.00} = 0.702$$

$$A_{8} = \frac{72.50}{36.20 + 39.00 + 23.80 + 28.70} = \frac{72.50}{127.70} = 0.57$$

$$A_{7} = \frac{77}{36.50 + 38.00 + 21.70 + 22.60} = \frac{77}{119.30} = 0.645$$

$$A_{6} = \frac{81.50}{37.80 + 39.60 + 22.50 + 23.70} = \frac{81.50}{123.60} = 0.660$$

$$A_{5} = \frac{86}{45.30 + 45.30 + 37.00 + 32.20} = \frac{86}{159.80} = 0.54$$

$$A_{4} = \frac{90.50}{57.50 + 57.80 + 39.20 + 49.00} = \frac{90.50}{203.00} = 0.455$$

$$A_{3} = \frac{94.50}{57.80 + 57.00 + 37.20 + 32.30} = \frac{94.50}{184.30} = 0.518$$

$$A_{2} = \frac{143.00}{47.50 + 44.00 + 29.20 + 27.80} = \frac{143.00}{148.50} = 0.960$$

$$A_{1} = \frac{135.00}{756 + 406 + 750 + 392} = \frac{135.00}{2300} = 0.0662$$

B Factors

$$B_{20a} = \frac{0.82}{0.98 + 0.53} = \frac{0.82}{1.51} = 0.542$$

$$B_{19a} = \frac{0.78 + 3.40}{2.18 + 1.48} = \frac{4.18}{3.66} = 1.14$$

$$B_{18a} = \frac{3.03 + 5.52}{4.10 + 2.66} = \frac{8.53}{6.76} = 1.26$$

$$B_{17a} = \frac{4.57 + 6.20}{6.72 + 4.17} = \frac{10.77}{10.89} = 0.99$$

$$B_{16a} = \frac{6.10 + 8.65}{12.20 + 7.42} = \frac{14.75}{19.62} = 0.75$$

$$B_{15a} = \frac{7.70 + 10.70}{14.40 + 8.95} = \frac{18.40}{23.35} = 0.79$$

$$B_{14a} = \frac{9.25 + 13.10}{1600 + 10.20} = \frac{22.35}{26.20} = 0.855$$

$$B_{13a} = \frac{11.50 + 13.60}{17.00 + 12.90} = \frac{25.10}{29.90} = 0.836$$

$$B_{12a} = \frac{14.30 + 16.70}{26.70 + 16.90} = \frac{31.00}{43.60} = 0.710$$

$$B_{11a} = \frac{15.30 + 18.50}{27.50 + 17.50} = \frac{33.80}{45.00} = 0.750$$

$$B_{10a} = \frac{16.30 + 20.00}{28.30 + 18.10} = \frac{36.30}{46.10} = 0.785$$

$$B_{9a} = \frac{18.10 + 19.40}{28.80 + 18.50} = \frac{37.50}{47.30} = 0.79$$

$$B_{8a} = \frac{20.20 + 22.20}{42.70 + 27.40} = \frac{42.40}{70.10} = 0.602$$

$$B_{7a} = \frac{20.60 + 24.80}{43.50 + 27.70} = \frac{45.40}{71.20} = 0.637$$

$$B_{6a} = \frac{23.50 + 26.20}{43.80 + 28.00} = \frac{49.70}{71.80} = 0.692$$

$$B_{5a} = \frac{25 + 24.50}{44.80 \cdot 28.20} = \frac{49.50}{72.40} = 0.682$$

$$B_{4a} = \frac{24.50 + 26.20}{62.00 + 41.00} = \frac{50.70}{103} = 0.49$$

$$B_{3a} = \frac{25.80 + 29.20}{62.50 + 41.00} = \frac{55.00}{103.50} = 0.532$$

$$B_{2a} = \frac{29.60 + 42.20}{62.10 + 41} = \frac{71.80}{103.10} = 0.700$$

$$B_{1a} = \frac{45.50 + 26.80}{61.80 + 40.60} = \frac{72.30}{102.40} = 0.710$$

K = 4.80 | K = 4.80 | K = 4.80 | K = 4.80 | K = 8.30 | K = 8.30 | K = 8.30 | K = 8.30 | K = 13.10 | K = 13.10 | K = 12.10 | K = 12.10 | K = 19.60

0.074, 0.037, 0.111 x 4.80 = 0.53, M = 0.29
0.78 = M
1.23 = 0.97 x 1.271
0.463
0.808
K = 0.97

0.192, 0.096, 0.288 x 4.80 = 1.48, M = 1.68
303 = M
1.98 = 1.92 x 1.034
0.404
0.630
K = 1.92

0.370, 0.185, 0.555 x 4.80 = 2.66, M = 3.35
4.57 = M
3.85 = 5.25 x 0.735
0.315
0.420
K = 5.25

0.580, 0.290, 0.870 x 4.80 = 4.17, M = 4.12
6.10 = M
6.82 = 11.20 x 0.610
0.210
0.400
K = 11.20

0.600, 0.300, 0.900 x 8.30 = 7.42, M = 5.56
7.70 = M
9.75 = 20.30 x 0.480
0.200
0.280
K = 20.30

0.720, 0.360, 1.080 x 8.30 = 8.95, M = 7.05
9.25 = M
10.80 = 33.80 x 0.320
0.140
0.180
K = 33.80

0.820, 0.410, 1.230 x 8.30 = 10.20, M = 8.70
11.50 = M
13.20 = 63 x 0.210
0.090
0.720
K = 63

0.880, 0.440, 1.320 x 8.30 = 12.50, M = 10.90
14.30 = M
17.60 = 88 x 0.200
0.060
0.140
K = 88

0.860, 0.430, 1.290 x 13.10 = 16.90, M = 12
15.30 = M
21.80 = 123 x 0.178
0.070
0.108
K = 123

0.892, 0.446, 1.338 x 13.10 = 17.50, M = 13.80
16.30 = M
21.80 = 162 x 0.134
0.054
0.080
K = 162

0.920, 0.460, 1.380 x 13.10 = 17.10, M = 14.20
18.10 = M
23.80 = 238 x 0.100
0.040
0.060
K = 238

0.940, 0.470, 1.410 x 13.10 = 18.50, M = 14.50
20.20 = M
28.70 = 293 x 0.098
0.030
0.068
K = 293

0.932, 0.466

0.53 = M
0.98 = 7.40 x 0.132
0.068
0.074
K = 7.40

0.926
0.404
1.330 x 0.97 = 1.29
M = 0.82
2.50 = M
2.18 = 7.40 x 0.295
0.103
0.192
K = 7.40

0.808
0.315
1.123 x 1.92 = 2.15
M = 3.40
5.18 = M
4.10 = 7.40 x 0.553
0.183
0.370
K = 7.42

0.630
0.210
0.840 x 5.25 = 4.40
M = 5.57
6.65 = M
6.72 = 7.40 x 0.911
0.331
0.580
K = 7.40

0.420
0.200
0.620 x 11.20 = 6.92
M = 6.20
9.20 = M
12.20 = 12.80 x 0.955
0.355
0.600
K = 12.80

0.400
0.140
0.540 x 20.30 = 11.00
M = 8.65
11.30 = M
14.40 = 12.80 x 1.125
0.405
0.720
K = 12.80

0.280
0.090
0.370 x 33.80 = 12.50
M = 10.70
13.65 = M
16.00 = 12.80 x 1.255
0.435
0.820
K = 12.80

0.180
0.060
0.240 x 63 = 15.10
M = 13.10
14.20 = M
17.00 = 12.80 x 1.335
0.455
0.880
K = 12.80

0.120
0.070
0.190 x 88 = 16.70
M = 13.60
19.00 = M
21.70 = 20.30 x 1.310
0.450
0.860
K = 20.30

0.140
0.054
0.194 x 123 = 23.80
M = 16.70
20.60 = M
27.50 = 20.30 x 1.357
0.465
0.892
K = 20.30

0.108
0.040
0.148 x 162 = 24.80
M = 18.50
22.10 = M
28.30 = 20.20 x 1.395
0.475
0.920
K = 20.30

0.080
0.030
0.110 x 238 = 26.20
M = 20
23.00 = M
28.50 = 20.30 x 1.420
0.480
0.940
K = 20.30

0.060
0.034
0.094 x 293 = 27.60
M = 19.40
25.90 = M
42.70 = 30.50 x 1.402
0.470
0.932
K = 30.50

0.068
0.027
0.095

0.116, M = 0.79
0.76 = M
1.19 = 0.97 x 1.236
0.442
0.794

0.206, M = 2.39
1.53 = M
1.50 = 0.97 x 1.031
0.397
0.634

0.366, M = 2.17
2.60 = M
2.18 = 3.33 x 0.655
0.317
0.338

0.662, M = 7.43
4.60 = M
5.13 = 11.20 x 0.459
0.169
0.290

0.710, M = 10.75
5.35 = M
6.80 = 20.30 x 0.335
0.145
0.190

0.810, M = 12.70
6.50 = M
7.60 = 33.80 x 0.225
0.095
0.130

0.870, M = 14.30
6.95 = M
8 = 51.50 x 0.155
0.065
0.090

0.910, M = 15.50
8.90 = M
10.90 = 75 x 0.745
0.045
0.100

0.900, M = 18.85
8.90 = M
12.60 = 105 x 0.120
0.050
0.070

0.930, M = 20.30
10.20 = M
13.70 = 162 x 0.085
0.035
0.050

0.936, M = 21.40
10.30 = M
13.60 = 210 x 0.065
0.025
0.040

0.960, M = 23.30
14.90 = M
21.20 = 266 x 0.080
0.020
0.060

0.948, M = 31.20

0.884
0.397
1.281 x 0.97 = 1.24
M = 0.79
K = 0.97

0.794
0.317
1.111 x 0.97 = 1.07
M = 1.63
K = 0.97

0.634
0.169
0.803 x 3.33 = 2.67
M = 3.17
K = 3.33

0.338
0.145
0.483 x 11.20 = 5.40
M = 4.83
K = 11.20

0.290
0.095
0.385 x 20.30 = 7.80
M = 6.15
K = 20.30

0.190
0.065
0.255 x 33.80 = 8.60
M = 7.35
K = 33.80

0.130
0.045
0.175 x 51.50 = 9
M = 7.80
K = 51.50

0.090
0.050
0.140 x 75 = 10.50
M = 8.55
K = 75

0.100
0.035
0.135 x 105 = 14.20
M = 9.95
K = 105

0.070
0.025
0.095 x 162 = 15.30
M = 11.40
K = 162

0.050
0.020
0.070 x 210 = 14.70
M = 11.20
K = 210

0.040
0.030
0.070 x 266 = 18.50
M = 13
K = 266

0.060
0.017
0.077

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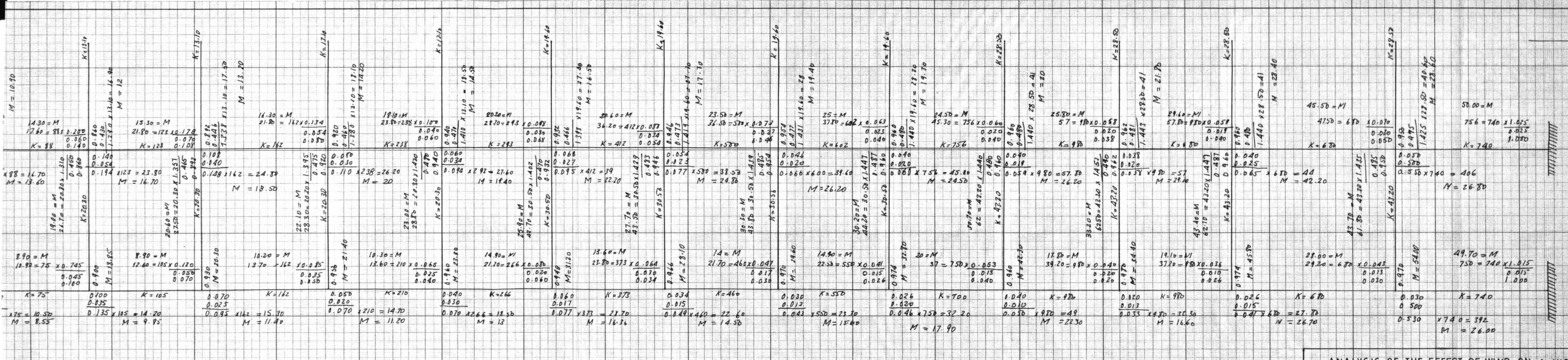

ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER :	RIAD SHAHIN	FACTOR METHOD
CHK'D BY :	RIAD SHAHIN	
APP'D BY :	D JACK NASSER	DATE : DECEMBER 1964 — SHEET Nº 21 /

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CASE C [1]

Introduction:

The analysis consists of:

1. Artificial T-beams whereby the flanges are provided merely to furnish sufficient area in compression and hence to improve the stiffness of the beams. The effective overhanging width will be assumed constant for all beams and taken as 50 cms. The depths of the beams will be changed every four floors as such 60, 70, 80, 90 and 100 cms.

2. Column sizes which have been reduced almost to half, resulting in values for stiffness which fall in the same order of the beams.

This arrangement implies the:

1. Use of high strength steel with an f_s = 2,100 Kg/cm^2=21,000 T/m^2.

2. Use of maximum allowable percentage of steel for the columns.

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(1) For dimensions of members refer to Chapter 3, Case C.

Beam And Column Factors

Joint	K_c I	K_c S	ΣK_c	$K_{g.}$	ΣK	g factor $\frac{\Sigma K_c}{\Sigma K}$	c. Factor (1 - g)
20	7.70	0	7.70	24.00	31.70	0.242	0.758
19-18-17	7.70	7.70	15.40	24.00	39.40	0.390	0.610
16	26.40	7.70	34.10	37.30	71.40	0.476	0.524
15-14-13	26.40	26.40	52.80	37.30	90.10	0.586	0.414
12	62.50	26.40	88.90	55.80	144.70	0.612	0.388
11-10-9	62.50	62.50	125.00	55.80	180.80	0.690	0.310
8	122.00	62.50	184.50	79.00	263.50	0.700	0.300
7-6-5	122.00	122.00	244.50	79.00	323.00	0.756	0.244
4	211.00	122.00	333.00	108.00	441.00	0.756	0.244
3	211.00	211.00	422.00	108.00	530.00	0.796	0.204
2	147.00	211.00	358.00	108.00	466.00	0.766	0.234
1	160.00	147.00	307.00	108.00	415.00	0.740	0.260

Joint a	K_g		ΣK_g	ΣK_c	ΣK	g. Factor $\frac{\Sigma K_c}{\Sigma K}$	c. Factor (1-g)
	K_{g1}	K_{g2}					
20	24.00	15.40	39.40	7.70	47.10	0.163	0.837
19-18-17	24.00	15.40	39.40	15.40	54.80	0.280	0.720
16	37.30	24.20	61.50	34.10	95.60	0.356	0.644
15-14-13	37.30	24.20	61.50	52.80	114.30	0.462	0.538
12	55.80	36.00	91.80	88.90	180.70	0.492	0.508
11-10-9	55.80	36.00	91.80	125.00	216.80	0.576	0.424
8	79.00	51.00	130.00	184.50	314.00	0.586	0.414
7-6-5	79.00	51.00	130.00	244.00	374.00	0.652	0.348
4	108.00	70.00	178.00	333.00	511.00	0.650	0.350
3	108.00	70.00	178.00	422.00	600.00	0.702	0.292
2	108.00	70.00	178.00	358.00	536.00	0.670	0.330
1	108.00	70.00	178.00	307.00	485.00	0.632	0.368

A Factors

$$A_{20} = \frac{6.30}{2(8.75 + 8.60 + 7.60 + 8.16)} = \frac{3.15}{33.11} = 0.095$$

$$A_{19} = \frac{18.90}{2(8.30 + 8.30 + 7.02 + 7.02)} = \frac{9.45}{30.64} = 0.308$$

$$A_{18} = \frac{31.20}{2(8.30 + 8.30 + 7.02 + 7.02)} = \frac{15.60}{30.64} = 0.510$$

$$A_{17} = \frac{43.50}{2(7.70 + 8.00 + 6.35 + 6.70)} = \frac{21.75}{28.75} = 0.757$$

$$A_{16} = \frac{55.80}{2(22.70 + 24.00 + 17.80 + 19.30)} = \frac{27.90}{83.80} = 0.332$$

$$A_{15} = \frac{67.50}{2(21.30 + 21.30 + 16.40 + 16.40)} = \frac{33.75}{75.40} = 0.447$$

$$A_{14} = \frac{79.00}{2(21.30 + 21.30 + 16.40 + 16.40)} = \frac{39.50}{75.40} = 0.521$$

$$A_{13} = \frac{91.00}{2(20.50 + 20.90 + 15.70 + 16.00)} = \frac{45.50}{73.10} = 0.621$$

$$A_{12} = \frac{102.00}{2(41.30 + 45.60 + 31.50 + 34.00)} = \frac{51.00}{152.40} = 0.334$$

$$A_{11} = \frac{113.00}{2(39.60 + 39.60 + 29.00 + 29.00)} = \frac{56.50}{137.20} = 0.412$$

$$A_{10} = \frac{120.00}{2(39.60 + 39.60 + 29.00 + 29.00)} = \frac{60.00}{137.20} = 0.436$$

$$A_{9} = \frac{135.00}{2(39.00 + 39.40 + 28.50 + 28.70)} = \frac{67.50}{135.60} = 0.500$$

$$A_{8} = \frac{145.00}{2(67.50 + 71.70 + 48.00 + 51.30)} = \frac{72.50}{238.50} = 0.304$$

$$A_{7} = \frac{154.00}{2(63.70 + 63.70 + 44.60 + 44.60)} = \frac{77.00}{216.60} = 0.355$$

$$A_{6} = \frac{163.00}{2(63.70 + 63.70 + 44.60 + 44.60)} = \frac{81.50}{216.60} = 0.375$$

$$A_{5} = \frac{172.00}{2(63.90 + 63.80 + 44.60 + 44.60)} = \frac{86.00}{216.90} = 0.396$$

$$A_{4} = \frac{181.00}{2(98.10 + 104.20 + 68.50 + 72.70)} = \frac{90.50}{343.50} = 0.263$$

$$A_{3} = \frac{189.00}{2(100.00 + 96.00 + 70.80 + 67.50)} = \frac{94.50}{334.30} = 0.283$$

$$A_{2} = \frac{286.00}{2(78.20 + 75.40 + 55.20 + 53.40)} = \frac{143.00}{262.20} = 0.545$$

$$A_{1} = \frac{270.}{2(189.00 + 138.00 + 180.00 + 121.00)} = \frac{135.00}{628.00} = 0.215$$

B Factors

$$B_{20a} = \frac{0.82}{680 + 3.76} = \frac{0.82}{10.56} = 0.078$$

$$B_{19a} = \frac{0.83 + 2.55}{11.40 + 6.45} = \frac{3.38}{17.85} = 0.19$$

$$B_{18a} = \frac{2.55 + 4.22}{11.40 + 6.45} = \frac{6.77}{17.85} = 0.38$$

$$B_{17a} = \frac{4.22 + 6.05}{11.40 + 6.40} = \frac{10.27}{17.85} = 0.576$$

$$B_{16a} = \frac{5.80 + 7.95}{22.10 + 12.90} = \frac{13.75}{35.00} = 0.392$$

$$B_{15a} = \frac{7.52 + 9.50}{28.10 + 16.70} = \frac{17.02}{44.80} = 0.38$$

$$B_{14a} = \frac{9.50 + 11.10}{28.10 + 16.70} = \frac{20.60}{44.80} = 0.46$$

$$B_{13a} = \frac{11.10 + 13.00}{28.10 + 16.70} = \frac{24.10}{44.80} = 0.538$$

$$B_{12a} = \frac{12.70 + 15.20}{44.40 + 26.50} = \frac{27.90}{70.90} = 0.393$$

$$B_{11a} = \frac{13.80 + 16.30}{15.20 + 31.00} = \frac{30.10}{82.20} = 0.365$$

$$B_{10a} = \frac{16.30 + 17.30}{51.20 + 31.00} = \frac{33.60}{82.20} = 0.408$$

$$B_{9a} = \frac{17.30 + 19.70}{51.20 + 31.00} = \frac{37.00}{82.20} = 0.450$$

$$B_{8a} = \frac{19.50 + 21.70}{73.80 + 44.60} = \frac{41.20}{118.40} = 0.348$$

$$B_{7a} = \frac{20.50 + 22.60}{81.00 + 49.70} = \frac{43.10}{130.70} = 0.330$$

$$B_{6a} = \frac{22.60 + 23.80}{81.00 + 49.70} = \frac{46.40}{130.70} = 0.355$$

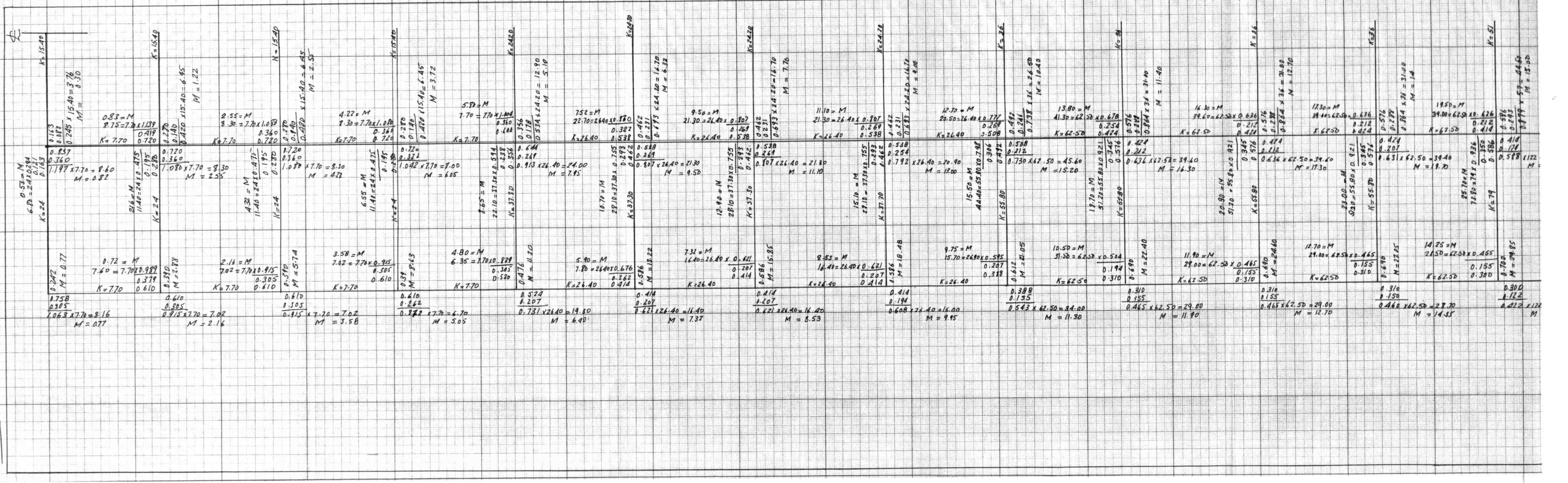
$$B_{5a} = \frac{23.80 + 25.10}{81.00 + 49.70} = \frac{48.90}{130.70} = 0.374$$

$$B_{4a} = \frac{25.20 + 27.40}{111.00 + 68.00} = \frac{52.60}{179.00} = 0.294$$

$$B_{3a} = \frac{25.70 + 27.10}{119.00 + 73.30} = \frac{52.80}{192.30} = 0.275$$

$$B_{2a} = \frac{28.30 + 41.00}{113.00 + 70.00} = \frac{69.30}{183.00} = 0.380$$

$$B_{1a} = \frac{42.60 + 29.60}{180.00 + 66.30} = \frac{72.20}{174.30} = 0.415$$



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<u>Checking Results of Factor Method</u>

$R_1 + R_2 = \frac{40.60 + 29.60 + 38.60 + 26.20}{4.50} = \frac{135.00}{4.50} = 30$

$\Sigma F_x = 60 - 2 \times 30 = 0$

$\therefore$ O.K.

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ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING	
Comparison of Approximate and Exact Methods	
COMPUTER : RIAD SHAHIN	FACTOR METHOD
CHK'D BY : RIAD SHAHIN	
APP'D BY : Dr JACK NASSER	DATE : DECEMBER 1964 — SHEET No 27

CHAPTER THREE

HARDY CROSS METHOD

CASE A

<u>Physical Constants</u>

Joint	K_g R	K_c I	K_c S	ΣK	Distribution factors I	Distribution factors R	Distribution factors S	F.E.M $(-6EK\Delta/l)$ T-m
20	2.70	0.97	0	3.67	0.26	0.74	00	- 2.00
19	2.70	0.97	0.97	4.64	0.21	0.58	0.21	- 2.00
18	2.70	3.33	0.97	7.00	0.48	0.48	0.14	- 6.00
17	2.70	11.30	3.33	17.33	0.65	0.16	0.19	- 20.00
16	3.20	20.30	11.30	34.80	0.58	0.09	0.33	- 35.70
15	3.72	33.80	20.30	57.82	0.58	0.07	0.35	- 60.00
14	4.30	51.50	33.80	89.60	0.57	0.05	0.38	- 90.00
13	4.80	76.00	51.50	132.30	0.57	0.04	0.39	- 134.00
12	5.35	105.00	76.00	186.35	0.56	0.04	0.40	- 185.00
11	6.48	162.00	105.00	273.48	0.59	0.02	0.39	- 285.00
10	7.00	210.00	162.00	379.00	0.55	0.02	0.43	- 360.00
9	7.50	270.00	210.00	489.50	0.55	0.02	0.43	- 475.00
8	8.56	373.00	270.00	651.56	0.57	0.01	0.42	- 658.00
7	8.90	460.00	373.00	841.90	0.55	0.01	0.44	- 810.00
6	8.90	550.00	460.00	1018.90	0.54	0.01	0.45	- 970.00
5	9.70	710.00	550.00	1269.70	0.56	0.01	0.43	- 1250.00
4	10.30	980.00	710.00	1700.30	0.57	0.01	0.42	- 1730.00
3	10.70	980.00	980.00	1970.70	0.495	0.010	0.495	- 1730.00
2	11.30	680.00	980.00	1671.30	0.41	0.01	0.58	- 830.00
1	11.30	740.00	680.00	1431.30	0	0.51	0.01	- 985.00

Joint a	K_{g2}	K_c	K_{g1}	K_{g2} Mod	K_c	ΣK	Distribution factors				F. E. M. (-6EK Δ/h)
		S	L	R	I		S	L	R	I	T·m
20	1.74	0	2.70	2.60	0.97	6.17	0	0.42	0.42	0.16	- 2.00
19	1.74	0.97	2.70	2.60	1.92	8.19	0.12	0.33	0.92	0.23	- 3.40
18	1.74	1.92	2.70	2.60	5.25	12.47	0.15	0.22	0.21	0.42	- 9.30
17	1.74	5.25	2.70	2.60	11.30	21.85	0.24	0.12	0.12	0.52	-20.00
16	2.08	11.30	3.20	3.12	20.30	37.92	0.30	0.09	0.08	0.53	-36.00
15	2.42	20.30	3.72	3.62	33.80	61.44	0.33	0.06	0.06	0.55	-60.00
14	2.78	33.80	4.30	4.16	63.00	105.26	0.32	0.04	0.04	0.60	-111.00
13	3.10	63.00	4.80	4.65	89.00	161.45	0.39	0.03	0.03	0.55	-157.00
12	3.46	89.00	5.35	5.20	123.00	222.55	0.40	0.026	0.024	0.55	- 217.00
11	4.15	123.00	6.42	6.22	162.00	297.64	0.41	0.02	0.02	0.55	-285.00
10	4.50	162.00	7.00	6.75	238.00	414.00	0.39	0.018	0.017	0.575	-420.00
9	4.85	238.00	7.50	7.25	298.00	550.75	0.435	0.013	0.012	0.54	-525.00
8	5.50	298.00	8.66	8.25	412.00	726.81	0.41	0.01	0.01	0.57	-725.00
7	5.70	412.00	8.90	8.52	500.00	929.42	0.44	0.01	0.01	0.54	-880.00
6	5.70	500.00	8.90	8.52	600.00	1118.00	0.45	0.01	0.01	0.53	-1050.00
5	6.25	600.00	9.70	9.35	770.00	1389.00	0.43	0.01	0.01	0.55	- 143.00
4	6.62	770.00	10.30	9.90	980.00	1770.00	0.43	0.01	0.01	0.55	-1730.00
3	6.92	980.00	10.70	10.40	980.00	1981.00	0.49	0.01	0.01	0.49	-1730.00
2	7.30	980.00	11.30	10.90	680.00	1682.00	0.58	0.01	0.01	0.40	- 830.00
1	7.30	680.00	11.30	10.90	740.00	1442.20	0.47	0.01	0.01	0.51	- 985.00

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Joint	Member	Dist. Factor
A0	S	0
1	I	0.5
	R	0.0
	S	0.48
2	I	0.41
	R	0.01
	S	0.58
3	I	0.495
	R	0.010
	S	0.495
4	I	0.570
	R	0.01
	S	0.42
5	I	0.56
	R	0.01
	S	0.43
6	I	0.52
	R	0.01
	S	0.45
7	I	0.55
	R	0.01
	S	0.44
8	I	0.57
	R	0.01
	S	0.42
9	I	0.55
	R	0.02
	S	0.43
10	I	0.55
	R	0.02
	S	0.43
11	I	0.54
	R	0.02
	S	0.30
12	I	0.56
	R	0.03
	S	0.01
13	I	0.57
	R	0.04
	S	0.39
14	I	0.57
	R	0.05
	S	0.38
9a	S	0.435
	L	0.0130
	R	0.0120
	I	0.540
8a	S	0.41
	L	0.01
	R	0.01
	I	0.57
7a	S	0.44
	L	0.01
	R	0.01
	I	0.54
6a	S	0.45
	L	0.01
	R	0.01
	I	0.53
5a	S	0.43
	L	0.01
	R	0.01
	I	0.55
4a	S	0.41
	L	0.01
	R	0.01
	I	0.55
3a	S	0.49
	L	0.01
	R	0.01
	I	0.49
2a	S	0.58
	L	0.01
	R	0.10
	I	0.40
1a	S	0.47
	L	0.01
	R	0.01
	I	0.51
0	S	0

Influence of Δ1 on Exterior Column

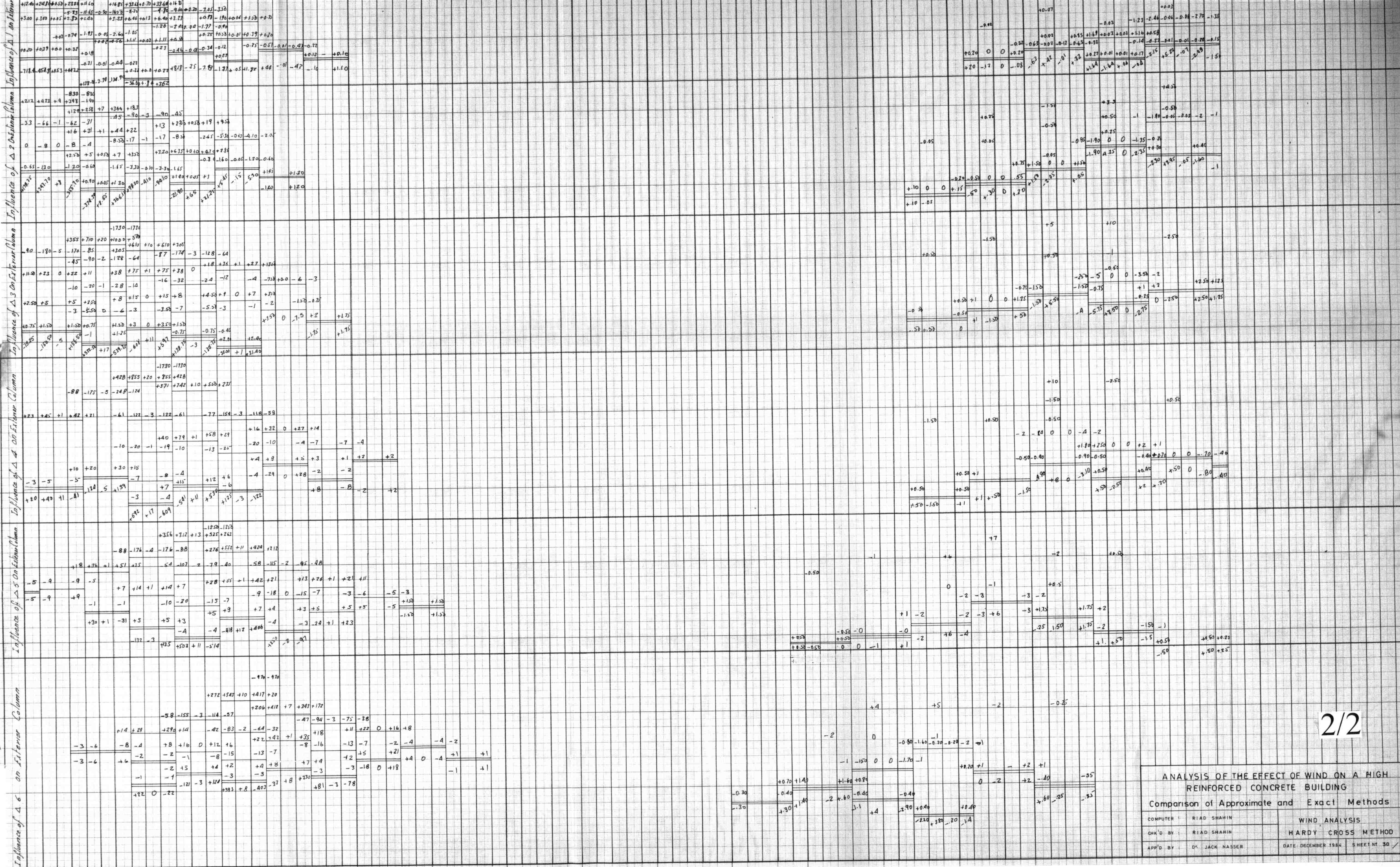
Influence of Δ2 on Exterior Column

Influence of Δ3 on Exterior Column

Influence of Δ4 on Exterior Column

Influence of Δ5 on Exterior Column

Exterior Column



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ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER : RIAD SHAHIN

CHK'D BY : RIAD SHAHIN

APP'D BY : Dr. JACK NASSER

WIND ANALYSIS

HARDY CROSS METHOD

DATE: DECEMBER 1964 SHEET No. 30

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JOINT	0	1			2			3			4			5			6			7			8			9			10			11			12			13			14			15			16			17			18			19			20		
MEMBER	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	–
DIST. FACTOR	0	0.51	0.01	0.48	0.41	0.01	0.58	0.492	0.010	0.412	0.570	0.01	0.42	0.56	0.01	0.43	0.54	0.01	0.45	0.55	0.01	0.44	0.57	0.01	0.42	0.55	0.02	0.43	0.55	0.02	0.43	0.59	0.02	0.39	0.56	0.04	0.40	0.57	0.04	0.39	0.57	0.05	0.39	0.59	0.07	0.35	0.58	0.09	0.33	0.65	0.16	0.19	0.48	0.38	0.14	0.21	0.58	0.21	0.26	0.74	–			

JOINT	20a			19a				18a				17a				16a				15a				14a				13a	
MEMBER	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R
DIST. FACTOR	0.42	0.42	0.16	0.12	0.33	0.32	0.33	0.16	0.22	0.21	0.42	0.24	0.12	0.12	0.52	0.30	0.09	0.08	0.53	0.33	0.06	0.06	0.55	0.32	0.04	0.04	0.60	0.39	0.03	0.03

Influence of Δ 7 on Exterior Column

-810 -810
+218 +436 +10 +364 +182
-61 -122 -2 -94 -48 +173 +346 +6 +276 +138
+17 +34 +1 +26 +13 -34 -68 -1 -56 -28 -39 -78 -2 -58 -29
-4 -8 -1 -8 -4 +6 +12 0 +9 +5 +18 +36 +1 +30 +15 +8 +16 +1 +12 +6
+1 +2 +2 +1 -0.50 -1 -1 -6 -12 -1 -10 -5 -7 -13 0 -10 -5 -2 -3 -3
-0.25 -0.50 -0.50 +2 -2 -25 -25 +29 +1 -30 +3 +3 +2 +4 +7 +5 +3 +2 +4 +3 +2
-25 -50 +0.50 -3.25 -1 +3.25 -3 -2 -14 +1 +13 -1 -1
-3 -3 -3 -272 +7 +265 +4 -4
+1 +1 +62 -2 -60
-93 -2 +95 +319 +9 -320

Influence of Δ 8 on Exterior Column

-658 -658
+181 +362 +6 +290 +145
-49 -98 -2 -81 -41 +146 +292 +5 +216 +108
+13 +27 +1 +21 +11 -29 -58 -1 -46 -23 -30 -60 -2 -46 -23
-4 -7 -6 -3 +5 +10 0 +8 +4 +15 +30 +1 +22 +11 +7 +13 +10 +5
+1 +2 +2 -7 +7 -1 -1 -0.50 -5 -10 -1 -8 -4 -5 -10 -8 -4
-0.40 -0.60
-40 +40 +2 -2 +23 +1 -24 +3 +5 +4 +2
-1 -2 -1 -213 +6 +207 -1 -1 -0.50
+2.50 +3 +255 +4 -259 +50 -2 -48 +2.50 +2 +1
-74 -2 +76 -12 +12 -3 -3 -2
+3 -3 +1 +1
-1 +1

Influence of Δ 9 on Exterior Column

-475 -475
+135 +270 +5 +200 +100
-37 -74 -2 -59 -30 +103 +206 +8 +161 +81
+10 +20 +17 +9 -21 -42 -1 -30 -15 -22 -44 -2 -35 -18
-3 -6 -4 -2 +4 +7 +5 +3
+1 +2 +1 +6.50 +10 +20 +1 +16 +8 +5 +10 +1 +7
-0.50 -0.50 0 0 -0.50 -1 -1 -4 -7 -6 -4 -8 -6 -3
-50 +50 +2 -2 -5.50 +5.50 +17 -17 +2 +2 +194 +4 -198 +2 +2 +1 +2 +1
-56 -2 +58 -162 +9 +153 -0.50 -0.50 -9 +1 +8 +4
+37.50 -2 -35.50 -2 -2
+2 -2

Influence of Δ 10 on Exterior Column

-360 -360
+99 +198 +8 +154 +77
-78 +156 +5 +122 +61
-28 -56 -1 -42 -21 -18 -36 -1 -24 -12
+8 +15 0 +13 +7 -16 -31 -1 -25 -13
-3 -5 -8 -2 +3 +5 +4 +2 +9 +17 +1 +13 +7 +4 +7 +5 +3
+1 +2 +1 -1 0 -3 -6 -5 -3
-0.50 -0.50 -3 -6 0 -5 -3 +1 +2 +4 0.50
-50 +50 +2 -2 -5 +3 +12 -12 +2 +1 +0.50 -1.50 +3 +3 +2 -6 +6 -1.50 -1
-42 -1 +43 -1 -1 -123 +6 +117 -2 -1 +1 -1
+141.50 +7 -148.50 +36 -1 -25

...rior Column

-285 -285
-78 +156 +7 +122 +61
-22 -43 -2 -33 -17 +66 +132 +4 -88 +44
+6 +12 +1 +9 +5 -14 -27 -1 -21 -11 -12 -24 -2 -18 -9


Influence of Δ 7 on
Influence of Δ 8 on Exterior Column
Influence of Δ 9 on Exterior Column
Influence of Δ 10 On Exterior Column
Influence of Δ 11 On Exterior Column

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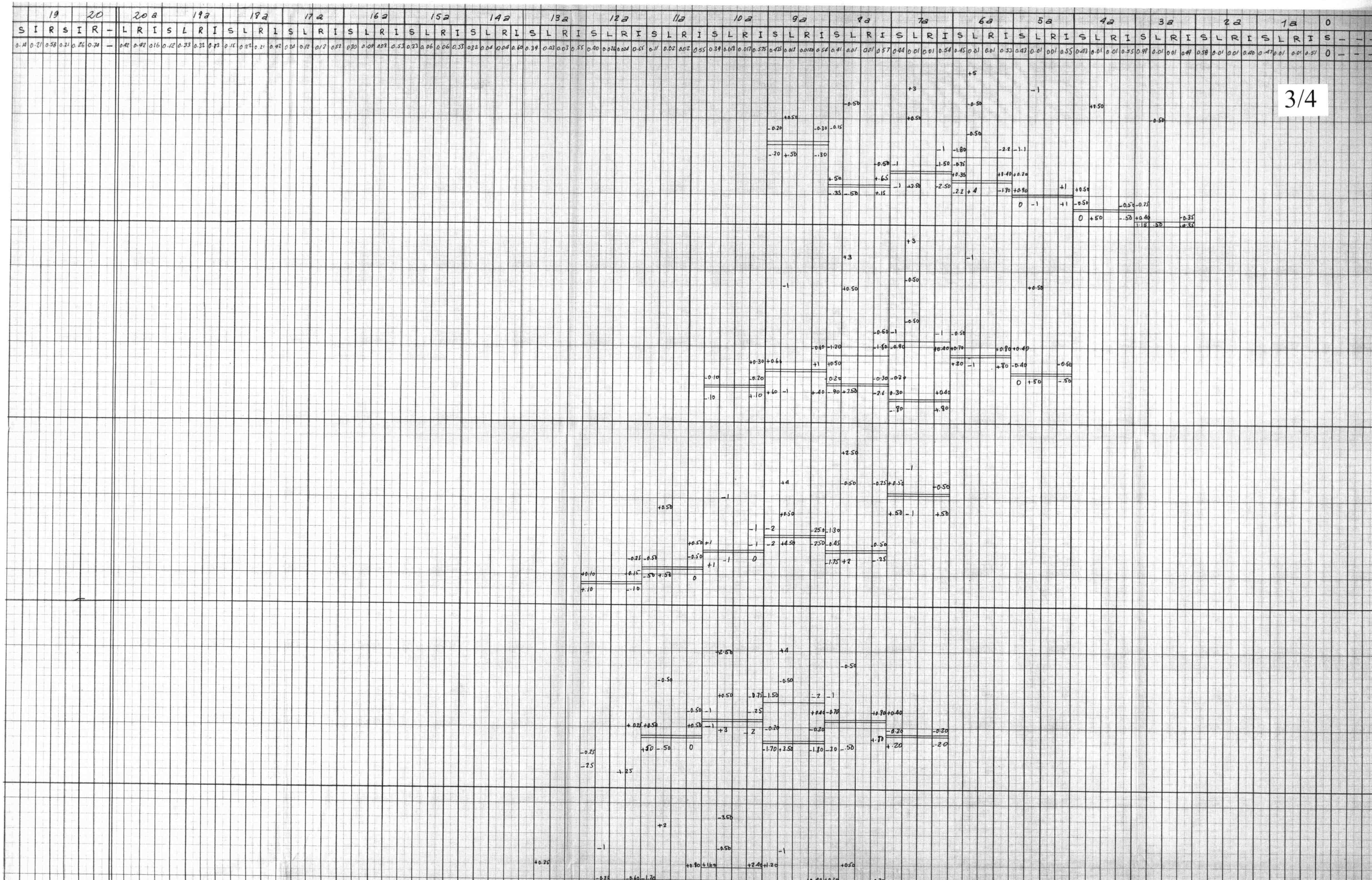

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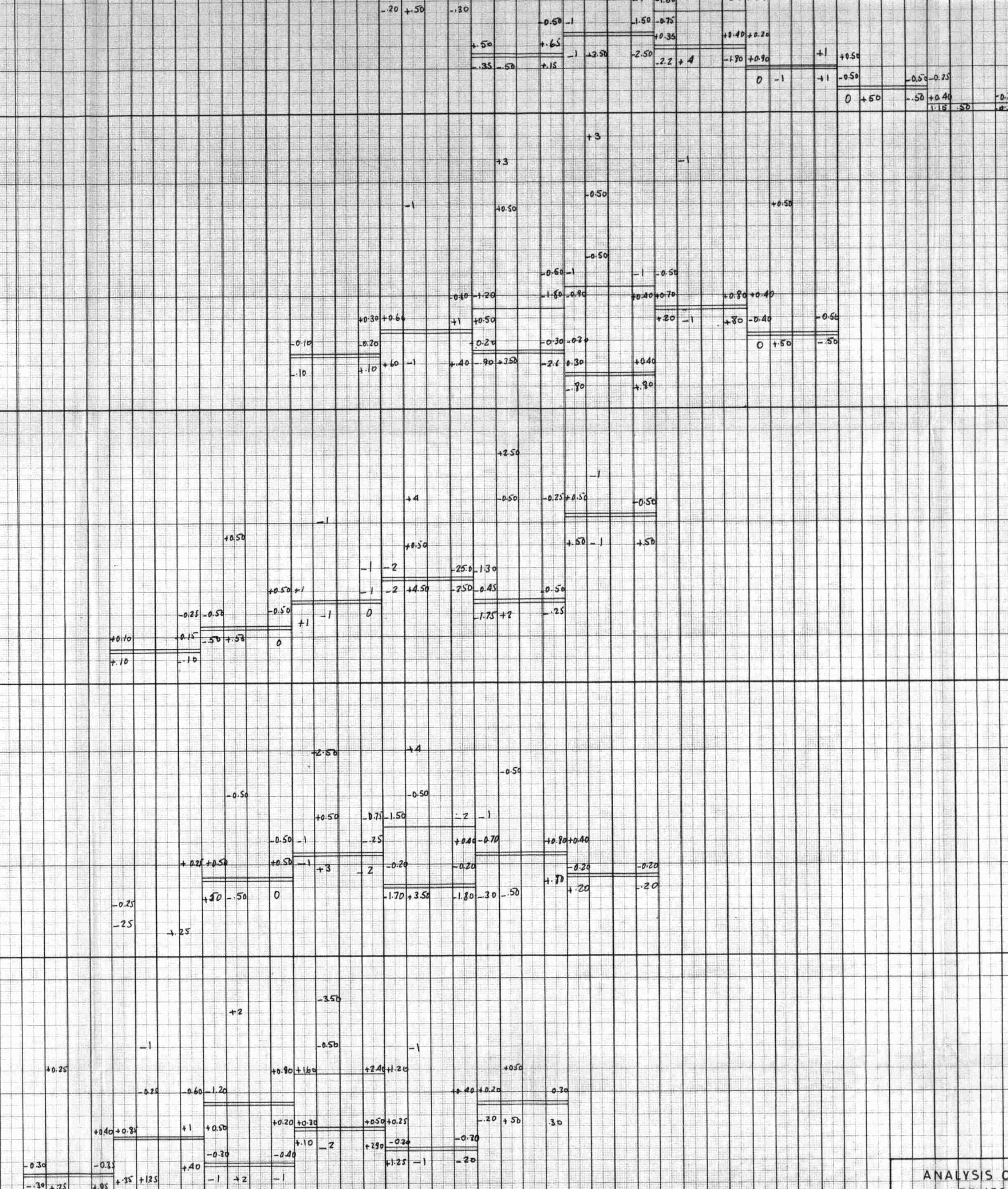

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ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING	
Comparison of Approximate and Exact Methods	
COMPUTER : RIAD SHAHIN	WIND ANALYSIS
CHK'D BY : RIAD SHAHIN	HARDY CROSS METHOD
APP'D BY : Dr. JACK NASSER	DATE : DECEMBER 1964 — SHEET No 31 /

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Influence of Δ 20 on Exterior Column	Influence of Δ 19 on Exterior Column	Influence of Δ 18 on Exterior Column	Influence of Δ 17 on Exterior Column	Influence of Δ 16 on Exterior Column	Influence of Δ 15 on Exterior Column	Influence of Δ 14 on Exterior Column	Influence of Δ 13 on Exterior Column	Influence of Δ 12 on Exterior Column	Dist. Factor	Member	Joint
											7
											8
											9
											10
											11
											12
											13
											14
											15
											16
											17
											18
											19
											20
											20a
											19a

	20		20a				19a				18a				17a				16a				15a				14a				13a				12a				11a				10a				9a				8a				7a	
S	I	R	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R
0.41	0.26	0.24	0.42	0.42	0.16	0.12	0.33	0.32	0.23	0.15	0.22	0.21	0.42	0.24	0.12	0.12	0.52	0.30	0.09	0.08	0.53	0.33	0.06	0.06	0.55	0.32	0.04	0.04	0.62	0.39	0.03	0.03	0.55	0.40	0.026	0.024	0.55	0.41	0.02	0.02	0.55	0.39	0.018	0.012	0.575	0.435	0.013	0.012	0.54	0.41	0.01	0.01	0.57	0.44	0.01	0.01

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ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER : RIAD SHAHIN		WIND ANALYSIS
CHK'D BY : RIAD SHAHIN		HARDY CROSS METHOD
APP'D BY : Dr. JACK NASSER	DATE: DECEMBER 1964	SHEET Nº 32

Influence of △5 on Interior Column

Influence of △4 on Interior Column

Influence of △3 on Interior Column

Influence of △2 on Interior Column

Influence of △1 on Interior Column

Joint	Member	Dist. Factor
0	S	0
1	I	0.51
1	R	0.01
1	S	0.48
2	I	0.41
2	R	0.01
2	S	0.58
3	I	0.495
3	R	0.010
3	S	0.495
4	I	0.570
4	R	0.01
4	S	0.42
5	I	0.56
5	R	0.01
5	S	0.43
6	I	0.54
6	R	0.01
6	S	0.45
7	I	0.55
7	R	0.01
7	S	0.44
8	I	0.57
8	R	0.01
8	S	0.42
9	I	0.55
9	R	0.02
9	S	0.43
10	I	0.55
10	R	0.02
10	S	0.43
11	I	0.59
11	R	0.02
11	S	0.39
12	I	0.56
12	R	0.04
12	S	0.40
13	I	0.57
13	R	0.04
13	S	0.39
14	I	0.57
14	R	0.05
14	S	0.38
15	I	0.58
15	R	0.07
15	S	0.35
16	I	0.58
16	R	0.09
16	S	0.33
17	I	0.65
17	R	[illegible]

		15			16			17			18			19			20		
R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	—
[illegible]	0.38	0.58	0.07	0.35	0.58	0.09	0.33	0.65	0.16	0.19	0.48	0.38	0.14	0.21	0.58	0.21	0.26	0.74	—

20a			19a				18a				17a				16a			
L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I
0.42	0.42	0.16	0.12	0.33	0.32	0.23	0.15	0.22	0.21	0.42	0.24	0.12	0.12	0.52	0.30	0.09	0.08	0.53

15a				14a				13a				12a				
S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S
0.33	0.06	0.06	0.55	0.32	0.04	0.04	0.60	0.39	0.03	0.03	0.65	0.40	0.026	0.024	0.55	0.01

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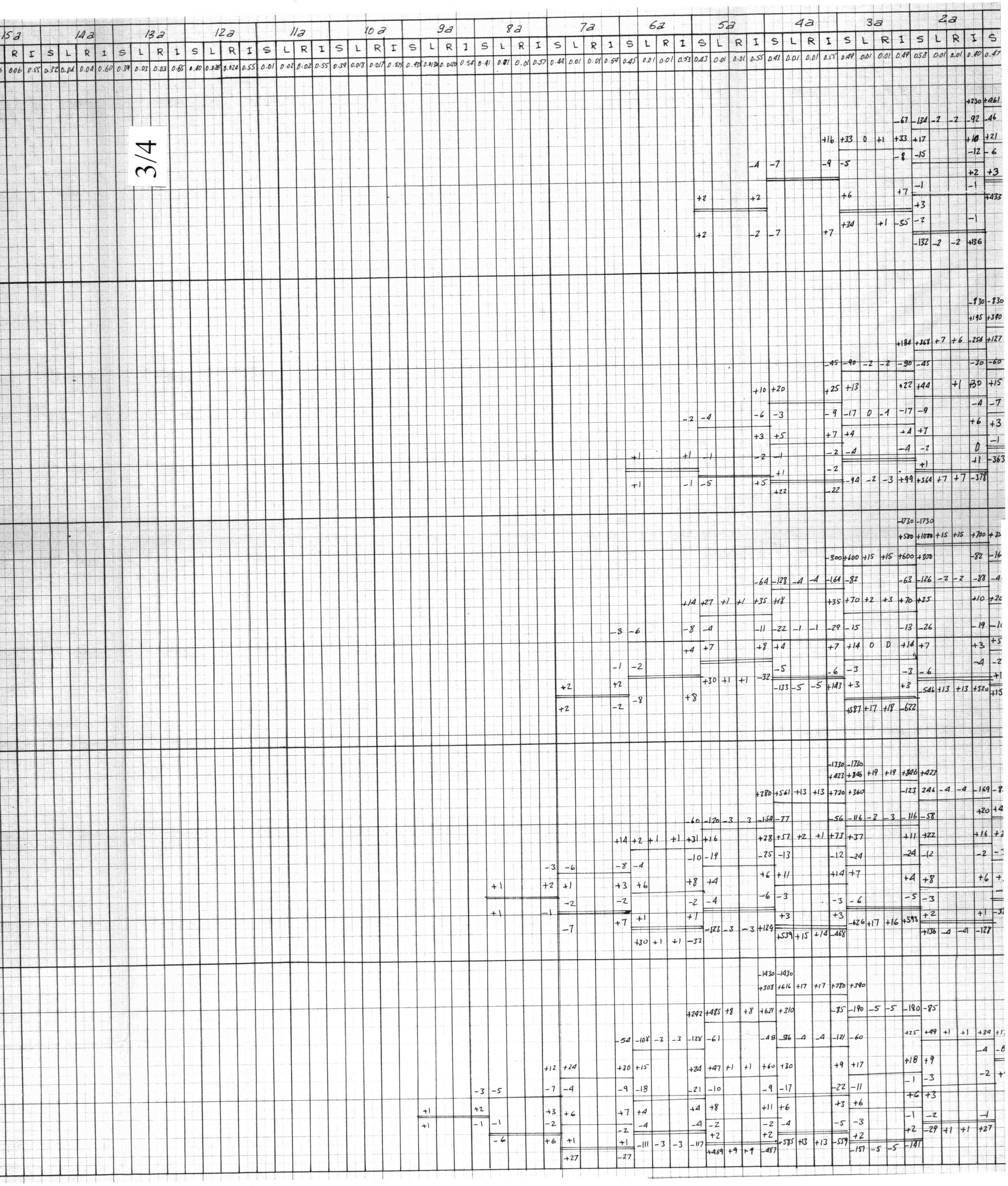

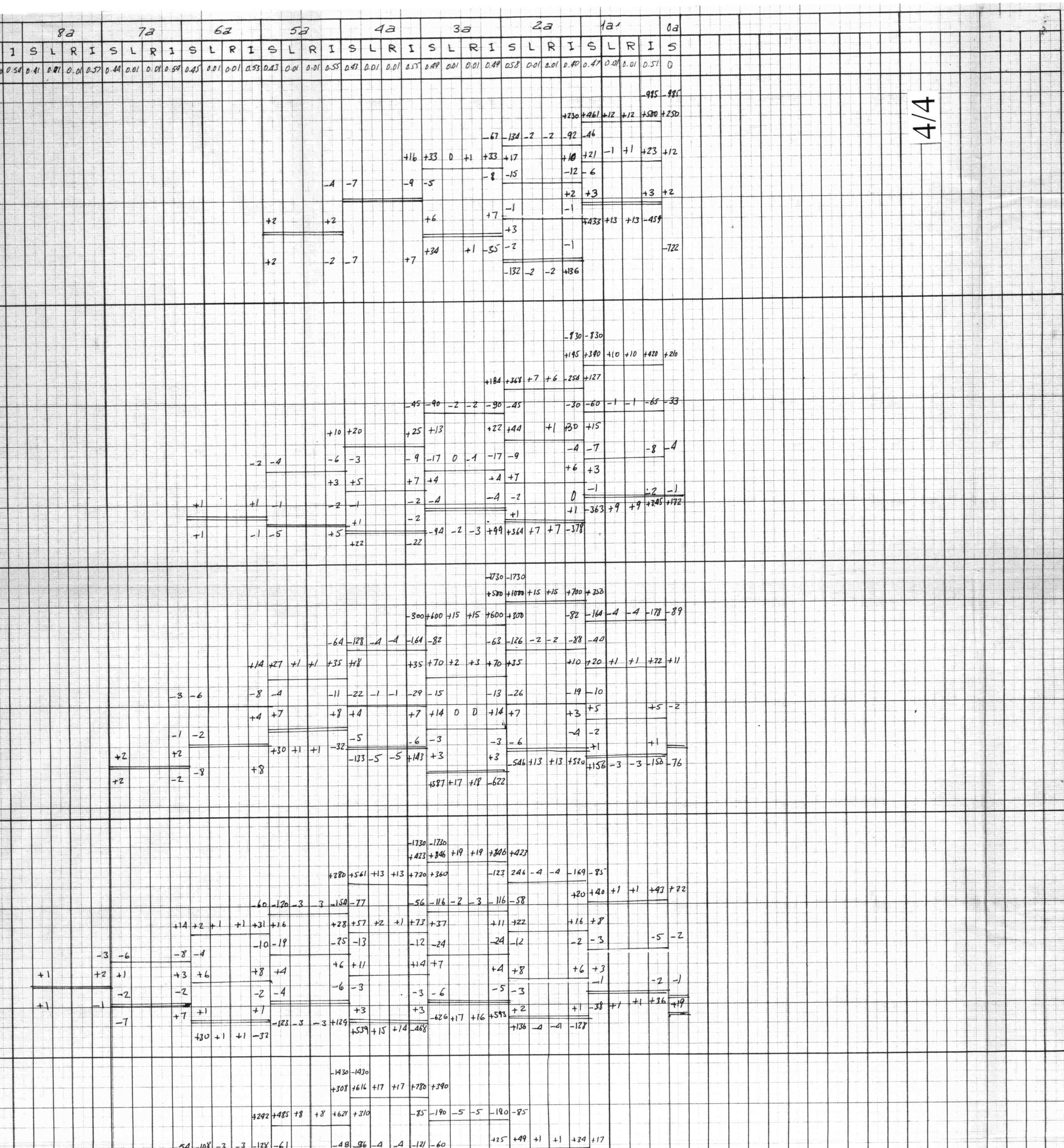

ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER : RIAD SHAHIN		WIND ANALYSIS
CHK'D BY : RIAD SHAHIN		HARDY CROSS METHOD
APP'D BY : Dr JACK NASSER	DATE : DECEMBER 1964	SHEET No 33 /

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Influence of △ 11 on Interior Column

Influence of △ 10 on Interior Column

Influence of △ 9 on Interior Column

Influence of △ 8 on Interior Column

Influence of △ 7 on Interior Column

Influence of △ 6 on Interior Column

Joint	Member	Dist Factor
—	—	—
0	S	0
1	I	0.57
	R	0.01
	S	0.48
2	I	0.41
	R	0.01
	S	0.58
3	I	0.495
	R	0.010
	S	0.495
4	I	0.516
	R	0.01
	S	0.42
5	I	0.58
	R	0.01
	S	0.43
6	I	0.54
	R	0.01
	S	0.45
7	I	0.55
	R	0.01
	S	0.44
8	I	0.57
	R	0.01
	S	0.42
9	I	0.55
	R	0.02
	S	0.43
10	I	0.55
	R	0.02
	S	0.43
11	I	0.59
	R	0.02
	S	0.39
12	I	0.58
	R	0.04
	S	0.40
13	I	0.57
	R	0.04
	S	0.39
14	I	0.59
	R	0.05
	S	0.32
15	I	0.58
	R	0.07
	S	0.35

12		13			14			15			16			17			18			19			20		
R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	—
0.04	0.40	0.57	0.04	0.39	0.59	0.05	0.37	0.58	0.07	0.35	0.58	0.09	0.33	0.65	0.16	0.19	0.48	0.38	0.14	0.21	0.58	0.21	0.26	0.74	—

20a				19a				18a				17a				16a				15a				14a				13a	
L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R
0.42	0.42	0.16	0.12	0.33	0.32	0.23	0.15	0.22	0.21	0.42	0.24	0.12	0.12	0.52	0.30	0.09	0.08	0.53	0.33	0.66	0.06	0.55	0.32	0.04	0.04	0.60	0.39	0.03	0.03

-1
-1

-50
+50
-50 +50

2/4

+2 +4
-1 -1
-1 +1 +1
+5

3/4

19a				18a				17a				16a				15a				14a			
S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I
0.12	0.33	0.32	0.23	0.15	0.22	0.21	0.42	0.24	0.12	0.12	0.52	0.30	0.09	0.08	0.53	0.33	0.66	0.06	0.55	0.32	0.04	0.04	0.60

13a				12a				11a				10a				9a				8a				7a				
S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S
0.39	0.03	0.03	0.55	0.40	0.026	0.024	0.55	0.41	0.02	0.02	0.55	0.39	0.018	0.017	0.575	0.435	0.0130	0.0120	0.54	0.41	0.01	0.01	0.57	0.44	0.01	0.01	0.54	0.45

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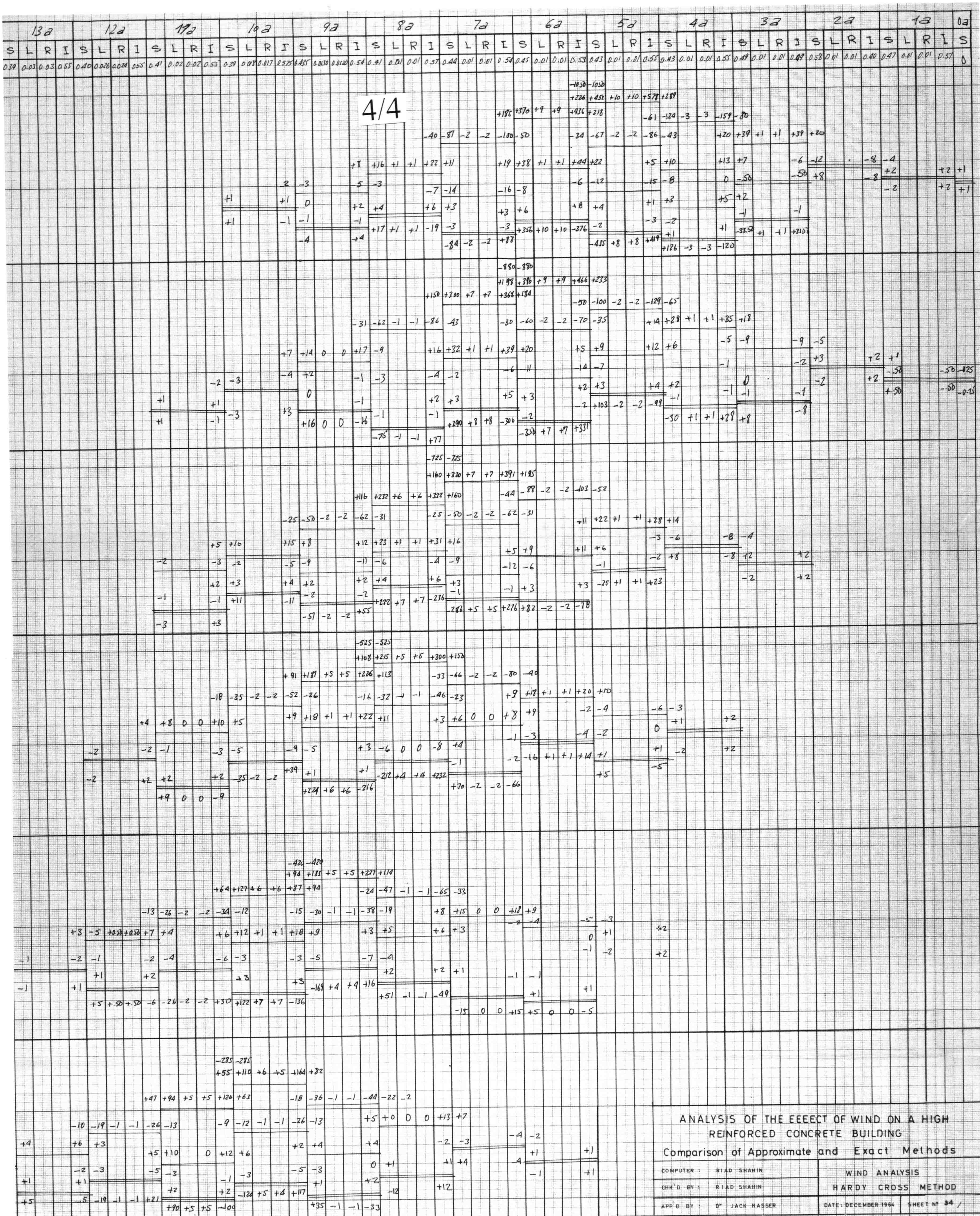

ANALYSIS OF THE EEECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER : RIAD SHAHIN	WIND ANALYSIS
CHK'D BY : RIAD SHAHIN	HARDY CROSS METHOD
APP'D BY : Dr JACK NASSER	DATE: DECEMBER 1964 SHEET No 34 /

JOINT	0	1			2			3			4			5			6			7			8			9			10		
MEMBER	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S
DIST. FACTOR	0	0.51	0.01	0.48	0.41	0.01	0.58	0.495	0.010	0.495	0.570	0.01	0.42	0.56	0.01	0.43	0.54	0.01	0.45	0.55	0.01	0.44	0.57	0.01	0.42	0.55	0.02	0.43	0.55	0.02	0.43

JOINT	11			12			13			14			15			16			17			18			19			20		
MEMBER	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	—
DIST. FACTOR	0.59	0.02	0.39	0.56	0.04	0.40	0.57	0.04	0.39	0.57	0.05	0.38	0.58	0.07	0.35	0.58	0.09	0.33	0.65	0.16	0.19	0.48	0.38	0.14	0.21	0.58	0.21	0.26	0.14	—

JOINT	20a			19a				18a				17a				16a				15a				14a				13a		
MEMBER	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R
DIST. FACTOR	0.42	0.42	0.16	0.17	0.33	0.32	0.23	0.15	0.22	0.21	0.42	0.24	0.12	0.12	0.52	0.30	0.09	0.08	0.53	0.33	0.06	0.06	0.55	0.34	0.04	0.04	0.60	0.39	0.03	0.0

Influence of Δ12 on Interior Column

-.5D +.25D +.25D
-1 -1.5D -1 -.5D
-1 -1 -.5D -.5D
+1 +.5D +.5D +.5D
+1 -.5D -.5D -1.5D +2.5D -1 -1.5D +2.5D -1 0 -.5D +.5D
-7 -14 -1
+4 +2
+2 +3
-1 -1 -3
-1 +1 +3 -3 -15 -1

Influence of Δ13 on Interior Column

-.5D
+2
+2
-.5D -1 -1 -.5D
+.5D +.5D -1 +2 -1 -1 -.5D
+.5D -.5D 0 -1.5D +2 +.5D
+23 +43 +4
-5 -9 -14 -7
+2 +3 +2 +3 +8
+2 -2 -2 -3 +43 +4
-9 +9

Influence of Δ14 on Interior Column

-.5D +1.5D
-.5D -1 -.5D -.25
+1.5D
+.5D +.5D -1 +1.5D -.5D -.75 -.5D
+.5D -.5D 0 -1 +1.5D -.5D
-11 -11
+22 +48 +3
+15 -20 +3 +3 +54 +27
-4 -7 -8 -4 -5 -9
+2 +2 +1 +2 +4 +5 +3
-1 -2 +29 +3 +3 -35 -2
+2 -2 -7 +7 -48 +3

Influence of Δ15 on Interior Column

-60 -60
+10 +20 +2 +2 +36 +18
+1
+1.5D
+8 +16 +3 +3 +27 +14 -4 -8
-2 -3 -5 -3 -2 -4 -6 -3
-.5D -1 -.5D
+1 +1 +2 +3 +2 0 +1
-.5D -1 +1.5D -.5D
+1 -1 -3 +3 +15 +3 +3 -21 -1 -1 +8
-.5D +1 -.5D -29 +2 +2 +25

Influence of Δ16 on Interior Column

-36 -36
+1
+6 +12 +2 +2 +20
+1.5D
+5 +9 +3 +2 +16 +8
-.5D 1 -.5D
-.5D +.5D -.5D -2 -2
-2 -3 -2 -1 -2 -4
-.50 +1 -.5D
-2 +2 +1 +2 -18 +2 +2 +14
+8 +3 +2 -13

Influence of Δ17 on Interior Column

-20 -20
+3 +6 +2 +2 +10 +5
+1
+1 +2 +4 +2 +2 +9 +5 -1 -2 -3 -2
-1
-20 -30 -60 -20 -20 -12D -04 -04D -2 +3 -3 +1 +1
-30 -20 0 0 0 -1 +4 +2 +2 -8 -1 +1
-30 +.8D -50 -60 +.80 -20 0 0 0 0 -162D +1.60 +1.60 +7

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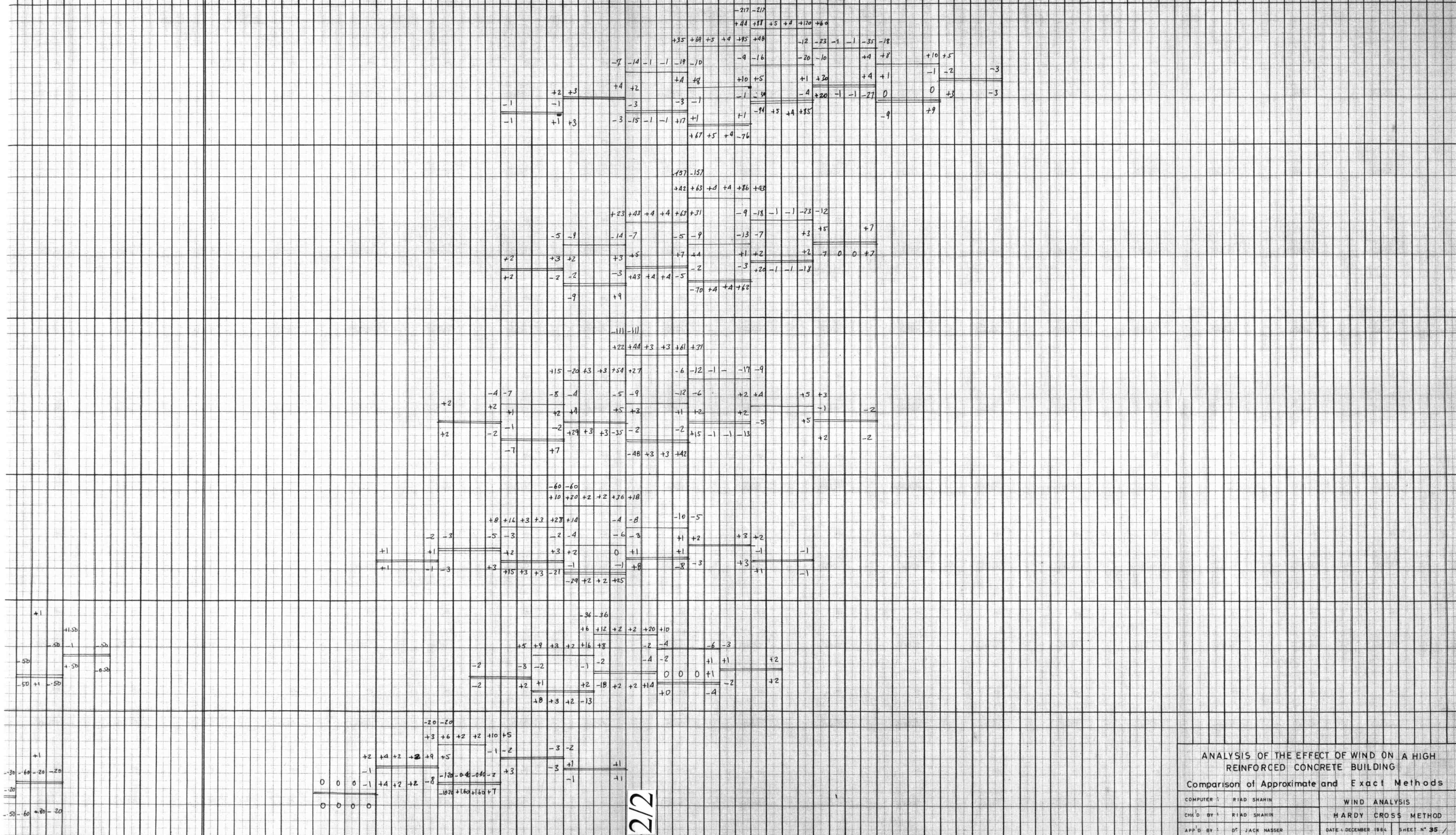
	17			18			19			20		
S	I	R	S	I	R	S	I	R	S	I	R	—
.33	0.65	0.16	0.19	0.48	0.38	0.14	0.21	0.58	0.21	0.26	0.14	—

20a			19a				18a				17a				16a			
L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I
0.42	0.42	0.16	0.17	0.33	0.32	0.23	0.15	0.22	0.21	0.42	0.24	0.12	0.12	0.52	0.30	0.09	0.08	0.53

15a				14a				13a				12a				11a			
S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I
0.33	0.06	0.06	0.55	0.34	0.04	0.04	0.60	0.39	0.03	0.03	0.55	0.40	0.026	0.024	0.55	0.41	0.02	0.02	0.55

10a				9a				8a				7a				6a			
S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I
0.39	0.018	0.017	0.575	0.43	0.0130	0.0120	0.54	0.41	0.01	0.01	0.57	0.44	0.01	0.01	0.54	0.45	0.01	0.01	0.53

5a				4a				3a				2a				1a				0
S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S
0.43	0.01	0.01	0.55	0.43	0.01	0.01	0.55	0.49	0.01	0.01	0.49	0.58	0.01	0.01	0.40	0.47	0.01	0.01	0.51	0



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ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER : RIAD SHAHIN	WIND ANALYSIS
CHK'D BY : RIAD SHAHIN	HARDY CROSS METHOD
APP'D BY : Dr JACK NASSER	DATE : DECEMBER 1964 — SHEET N° 35 /

Joint	16			17			18			19			20			20a		
Member	I	R	S	I	R	S	I	R	S	I	R	S	I	R	–	L	R	I
Dist. Factor	0.58	0.09	0.33	0.65	0.16	0.19	0.48	0.38	0.14	0.21	0.58	0.21	0.26	0.74	—	0.42	0.42	0.16
Influence of Δ 18 on Interior Column																		
					+0.60													
		-0.10						+0.90										
						-0.20	-0.40	-0.30	-0.20	-0								
					-0.10													
			-0.20	-0.30	0	0												
	+0.20																	
			+.10															
							-0.40	+0.60	-0.20									
	+0.20	-0.10	-0.10	-0.30	+0.50	-0.20												
Influence of Δ 19 on Interior Column																		
								+0.40										
											+0.50							+0.20
																-0.10	-.10	
										-0.20	-0.30							
							-0.20	-0.20										
							-0.20	+0.20	0	-0.20	+0.20					-0.10	-.10	+0.20
Influence of Δ 20 on Interior Column																		-2
											+0.4							+.1
										-.10	-.20	-.0	0	+.40		+.8	+.8	+3
										-.10	+.20	-.10	-.10	-.30				
																+.80	+.80	-1.60
													-.10	+.10				

Joint	19a				18a				17a				16a				15a				14a			
Member	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I
Dist. Factor	0.12	0.33	0.32	0.23	0.15	0.22	0.21	0.42	0.24	0.12	0.12	0.52	0.30	0.04	0.08	0.53	0.33	0.06	0.06	0.55	0.32	0.04	0.04	0.60
Influence of Δ 18 on Interior Column								-9.30	-9.50															
								+1.10	+2.2	+1.10	+1.10	+4.90	+2.50											
				+0.60	+1.20	+1.80	+1.70	+3.50	-1.80			-0.40	-0.80	-0.20	-0.20	-1.30	-0.70							
	-0.10	-0.20	-0.20	-0.10	0			-0.20	-0.30	-0.20	-0.20	-0.70	-0.40											
								+0.20					+0.20	0	0	+0.20	+0.10							
																	+0.20	0	0	+0.40	+0.20			
									-5.60	+0.90	+0.90	+3.10	+1.50	-0.20	-0.20	-1.10								
					+1.20	+1.80	+1.70	-4.70									-0.40	0	0	+0.40				-0.20
	-0.10	-0.20	0.20	+0.50																				
																					+0.20			-0.20
Influence of Δ 19 on Interior Column				-3.40	-3.40																			
				+0.30	+0.60	+0.70	+0.70	+1.40	+0.70															
								-0.10	-0.20	-0.10	-0.10	-0.30												
	+0.40	+1	+1	+0.70	+0.40																			
						-.10	-0.10	-0.10																
									+0.50	-0.10	-0.10	-0.30												
					+2.40	+0.60	+0.60	+1.20																
	+0.40	+1	+1	-2.40																				
Influence of Δ 20 on Interior Column	-2																							
	+.20	+.7	+.7	+.40	+20																			
	-1.80	+.70	+.70	+.40				-20																
					+20			-20																

Joint	13a				12a				11a				10a				9a				8a		
Member	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R
Dist. Factor	0.39	0.03	0.03	0.55	0.40	0.026	0.024	0.55	0.41	0.02	0.02	0.55	0.39	0.018	0.017	0.576	0.435	0.0150	0.0120	0.54	0.41	0.01	0.01

ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER : RIAD SHAHIN	WIND ANALYSIS	
CHK'D BY : RIAD SHAHIN	HARDY CROSS METHOD	
APP'D BY : Dr. JACK NASSER	DATE : DECEMBER 1964	SHEET No 36

DENOMINATION	C FACTOR (−z/h)	Δ1 +	Δ1 −	Δ2 +	Δ2 −	Δ3 +	Δ3 −	Δ4 +	Δ4 −	Δ5 +	Δ5 −	Δ6 +	Δ6 −	Δ7 +	Δ7 −	Δ8 +	Δ8 −
1	−0.588	ΣM=−2363.21	718.40 721 454.81 459 1.50 2 3.00 3.5 V=+1390	178.85 347.70 172 346 ΣM=+1037.45	1.00 1.60 3.00 V=−6.10	125 250 ΣM=−450.50	75.25 2.50 150.50 76 150 V=+266	20 40 55 ΣM=+113.55	0.40 0.80 0.25 V=−66.50	0.25 0.50 ΣM=−27.25	5 9 14 V=+16	0 3 ΣM=+3	V=−1.77	ΣM=−1.50	0.25 0.50 0.75 V=+0.88	0	0
2	1/3	443.28 138.24 433 136 ΣM=+1144.83	2.15 0.04 3.50 V=−670	ΣM=−1480.15	355.70 363 374.70 378 2.30 410 2.35 V=+870	155.50 522.75 156 520 ΣM=+1347.50	2.75 4.00 V=−820	0.30 2.10 1.75 ΣM=−336.95	41 134 128 38 V=+190	9 20 30 1.00 ΣM=+74.50	0.50 1.50 V=−43.80	ΣM=−19	3 6 10 V=+11.20	250 250 ΣM=+5	V=−2.95	ΣM=−0.40	0.40 V=+[illegible]
3		1.64 0.22 2.00 ΣM=−334.12	134.90 36.08 132.50 35 V=+197	366.15 98.20 0.55 369 99 ΣM=+924.10	1.90 1.90 V=−545	5.75 4.00 12.00 ΣM=−2292	539.75 608.00 546.00 622 V=+1640	139 592 593.50 136 ΣM=1454.40	3.10 300 V=−853	1 1.75 ΣM=−333.75	31 3.50 132 29 141 V=−198	6 22 ΣM=−12.60	0.35 39.50 0.75 V=+7.40	0.35 ΣM=−18.90	9.25 10.00 V=+11.10	2.40 2.00 ΣM=+4.40	V=−2.[illegible]
4		35.21 8.18 41 ΣM=+83.18	0.63 0.08 0.50 V=−49	150 0.20 0.75 ΣM=−229.55	94.10 21.90 94 22 V=+135	1.50 587.00 1430.0 ΣM=−2.25	597.00 138.75 0.50 2.50 V=+4.26	−2260 50 ΣM=−2157.90	609 626 541 468 4.90 1.50 11 V=+1270 +1330	135 503 151 559 ΣM+1341.75	3.25 3.00 V=−790	2.60 1.75 ΣM=292.15	22 121 120 33.50 V=+172	8.25 36 29.00 0.15 ΣM=+72.40	0.50 0.50 V=−42.60	ΣM=−19	9 10 V=+11.[illegible]
5		0.20 ΣM=−18.60	7.93 1.87 9 V=+10.90	21.25 5.45 27 ΣM=+52.90	0.50 0.05 0.25 V=−31	10.0 2.00 ΣM=−330.15	135.75 32.40 133 32 V=+195	530 129 125 539 1 1 ΣM=−1323	2 V=+780	7.50 ΣM=−2003.50	54 448 585 487 V=+1180	124 395 419 126 ΣM=+1061	1.40 1.50 V=−625	1 1 ΣM=−250	30 93 129.50 V=+147	30 31 ΣM=+60	0.50 0.50 V=−35
6		1.82 0.44 2.00 ΣM=+4.26	V=−2.50	0.10 ΣM=−12.40	5.30 1.20 6.00 V=+6.70	31.40 7.50 38.00 ΣM=+75.90	0.50 0.50 V=−44.60	0.50 1.75 ΣM=−302.75	122 28 123 32 V=+177	406 100 469 117 ΣM=+1090	2 V=−640	ΣM=−1563.10	403 435 338 376 220 6 290 V=+920	95 103 312 336 ΣM=+842.20	170 278 V=−495	ΣM=−199.20	24 74 25 78 V=+117
7		ΣM=−0.53	0.43 0.10 V=+0.31	1.20 1.00 ΣM=+20	V=−1.30	ΣM=−19.25	7.50 1.75 10.00 V=+11.30	28 8 37 ΣM=+72.75	0.25 V=−242.75	0.50 1.00 −257.50	97 24 111 27 V=+1.57	3.30 81.60 356 88 ΣM=+852.50	1.16 2.00 V=−502	ΣM=−1256.70	320 350 277 306 470 400 V=+735	76 276 255 82 1 ΣM=+689	1 V=−40
8		0.10 ΣM=−0.10	V=+0.06			1.75 2 ΣM=+3.75	V=−2.20	ΣM=−18	8 2 8 V=+1060	28 5 33 ΣM=+61	V=−36	1.70 1.00 Σ=−196.40	78 18.50 84 19 V=+115	265.15 62 290.00 77 ΣM=+692.15	1 1 V=−407	ΣM=−1001.40	259 213 3.40 4 V=+59
9								2 1 ΣM=+3	V=−17.60	ΣM=−13.50	5 1.50 7.50 V=+7.92	18 4 21 ΣM=+42.52	0.50 V=−25	0.50 ΣM=−167.15	75 74 0.65 91.00 V=+98	207 222 50 55 ΣM=+531.50	0.50 2.00 V=−312
10										1.50 1 ΣM=+2.50	V=−1.47	ΣM=−10	4 1 5 V=+5.90	17 19 ΣM=+35.80	0.20 V=−21	0.70 1.00 ΣM=−120.70	60 60 V=+70.[illegible]
11												1 1 ΣM=+2	V=−1.16	ΣM=−8	4 4 V=+4.70	15 14 ΣM=28.90	0.10 V=−17
12														1 ΣM=+1	V=−0.60	ΣM=−7	4 3 V=+4.12
13																1 ΣM=+1	V=−0.[illegible]
14																	
15																	
16																	
17																	
18																	
19	−0.408																
20	−0.444																

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Δ7 +	Δ7 −	Δ8 +	Δ8 −	Δ9 +	Δ9 −	Δ10 +	Δ10 −	Δ11 +	Δ11 −	Δ12 +	Δ12 −	Δ13 +	Δ13 −	Δ14 +	Δ14 −	Δ15 +
	0.25 0.50 0.75	0	0	0	0											
1.50	V=+0.88															
			0.40	0	0											
+5	V=-2.95	ΣM=-0.40	V=+0.24													
25	9.25 10.00	2.40 2.00			0.50											
-18.80	V=+11.10	ΣM=+4.40	V=-2.60	ΣM=-0.50	V=+0.30											
5 36	0.50 0.50		9 10	2.50 2.00			0.50									
172.40	V=-42.60	ΣM=-19	V=+11.20	ΣM=+4.50	V=-2.65	ΣM=0.50	V=+0.30									
1 1	30 93 129.50	30 31	0.50 0.50		7.50 7.00	2.50 2.00										
-250	V=+147	ΣM=+60	V=-35.30	ΣM=-14.50	V=+8.52	ΣM=+4.00	V=-2.65									
103 336	10 27	0.80 1.00	24 74 25 78	22.50 19	0.50		7 7	1 1								
1842.20	V=-495	ΣM=-119.20	V=+117	ΣM=+41	V=-24.20	ΣM=-14	V=+8.35	ΣM=+2	V=-1.17							
	320 357 277 306 470 400	76 276 255 82 1	1	0.50 0.60	17 56 82	+5 20 37.80	0.20		4 5	0.60						
-1256.70	V=+735	ΣM=+689	V=-406	ΣM=-154	V=+90.50	ΣM=+38.70	V=-22.20	ΣM=-9	V=+5.30	ΣM=+0.60	V=-0.35					
.15 .00	1 1		259 286 213 286 3.40 4	58 232 194.25 70	0.30	1.00 0.25	54 64	9.70 16	3.30 0.50		2.45 3	0.60			0.20	
+692.15	V=-407	ΣM=-1001.40	V=+590	ΣM=+553.95	V=-326	ΣM=-116.75	V=+68.50	ΣM=+22	V=-12.90	ΣM=-5.45	V=+3.20	ΣM=0.60	V=-0.35	ΣM=-0.20	V=+0.12	
.50	75 74 0.65 91.00	207 222 52 55	0.50 2.00	−795.15	158 212 162 216 425 290	48 191.50 57 161	2.10 0.25	2.00	10.70 45 31.40 0.40	1.85 6.30 11	0.20		2.60	0.80		
-167.15	V=+98	ΣM=+531.50	V=-312	ΣM=-784.25	V=+468	ΣM=+394.15	V=-232	ΣM=-85.50	V=+50.20	ΣM=+19.35	V=-11.30	ΣM=-2.60	V=+1.53	ΣM=+0.80	V=-0.47	
	0.20	0.70 1.00	60 60	153 37.50 224 39	2.50 1.10		148.50 136 123.00 3.50 3.70 169	33.40 35 109.00 117 2.90 1.25	2.50	0.90 1.00	6.50 22.25 36	7.00 7.00			2.60 2	0.30
+35.80	V=-21	ΣM=-120.70	V=+70.80	ΣM=+450.40	V=-266	ΣM=-582.70	V=+343	ΣM=+296	V=-74	ΣM=-62.75	V=+37	ΣM=+14	V=-8.35	ΣM=-4.60	V=+2.70	ΣM=+0.30
	4 4	15 14	0.10	1.70	35.90 9.00 44.50	117 26 152	1 1.50	0.10	115 2.50 39 226	24.25 77.00 29 85	0.20 2.00	0.50 0.50	22.00 25	7.00 7.00		
-8	V=+4.70	ΣM=28.90	V=-17	ΣM=-87.50	V=+51.20	ΣM=+292.50	V=-172	ΣM=-432.40	V=+253	ΣM=+213.05	V=-125	ΣM=-46	V=+27	ΣM=+14	V=-8.35	ΣM=-2.30
1			4 3	8 2 11.00	0.60	1	31.75 32.00	85 22 117	0.60 1.00		87 94 63 76 3.70 2.50	18 53 82	0.75 1.00	0.50 0.50	17.00 18	4.00 4.00
+1	V=-0.60	ΣM=-7	V=+4.12	ΣM=+20.40	V=-12	ΣM=-62.75	V=+36.70	ΣM=+216.40	V=-127	ΣM=-320.20	V=+189	ΣM=+151.25	V=-89	ΣM=-34.80	V=+20	ΣM=+8
		1		0.10	2 2	7 6	0.25	0.90 0.50	19.50 4.50 24	57 14 67 17	1.00 0.80	57 2.50 45 2.75 121.00		39.00 1.50 57.00 0.50 +1		0.50
		ΣM=+1	V=-0.60	ΣM=-3.40	V=+2.30	ΣM=+2.75	V=-7.58	ΣM=-46.60	V=+27.50	ΣM=+152.40	V=-92	ΣM=-228.25	V=+134	ΣM=+98.50	V=-58	ΣM=-21.50
							1 1	5 6	0.30	0.60 0.50	16 18	49.00 52	1.00 0.50		71.00 2.50 48 1.5 35	35.30 33
						ΣM=-2	V=+1.18	ΣM=+10.70	V=-6.30	ΣM=-32.90	V=+19.40	ΣM=+99.50	V=-58.50	ΣM=-157.50	V=+104	ΣM=+67.30
									1 1	3 4	0.10		10.00 0.50 11	33.00 36	1.20 0.50	
								ΣM=-2	V=+1.18	ΣM=+6.90	V=-4.06	ΣM=-21.50	V=+12.70	ΣM=+67.30	V=-39.58	ΣM=-100.80
											1	1.90 2.00	0.20		7.00 0.20 9	1960 18
										ΣM=-1	V=+0.60	ΣM=+3.70	V=-2.18	ΣM=-16.20	V=+9.52	ΣM=+36.85
													0.30	1.00 2.00		
												ΣM=-0.30	V=+0.18	ΣM=+3	V=-1.77	ΣM=-7.65
																0.40 1.00
																ΣM=+1.40

Δ12 +	Δ12 −	Δ13 +	Δ13 −	Δ14 +	Δ14 −	Δ15 +	Δ15 −	Δ16 +	Δ16 −	Δ17 +	Δ17 −	Δ18 +	Δ18 −	Δ19 +	Δ19 −	Δ20 +	Δ20 −
60																	
+0.60	V=-0.35																
	2.45 3	0.60			0.20												
-5.45	V=+3.20	ΣM=0.60	V=-0.35	ΣM=-0.20	V=+0.12												
5 8	0.20		2.60	0.80													
+19.35	V=-11.30	ΣM=-2.60	V=+1.53	ΣM=+0.80	V=-0.47												
0 0	6.50 22.75 36	7.00 7.00			2.60 2	0.30											
-62.75	V=+37	ΣM=+19	V=-8.35	ΣM=-4.60	V=+2.70	ΣM=+0.30	V=-0.18										
.25 .00	0.20 2.00	0.50 0.50	22.00 25	7.00 7.00			1.30 1										
+213.05	V=-125	ΣM=-46	V=+27	ΣM=+14	V=-8.35	ΣM=-2.30	V=+1.35										
	87 94 63 76 3.70 2.50	18 53 82	0.75 1.00	0.50 0.50	17.00 18	4.00 4.00											
-320.20	V=+189	ΣM=+151.25	V=-89	ΣM=-34.80	V=+20	ΣM=+8	V=+4.70										
7	1.00 0.80		57 2.50 45 2.75 121.00	39.00 1.50 57.00 +1 0.50		0.50	11.00 11	2.00 2									
-156.40	V=-92	ΣM=-228.25	V=+134	ΣM=+98.50	V=-58	ΣM=-21.50	V=+12.70	ΣM=+4	V=-2.35								
60 50	16 18	49.00 52	1.00 0.50		71.00 2.50 48 1.5 35	35.30 33	0.50 0.50	0.50	6.53 6	1.00 1.30 1.00			0.20				
-32.90	V=+19.40	ΣM=+99.50	V=-58.50	ΣM=-157.50	V=+104	ΣM=+67.30	V=-39.70	ΣM=-12	V=+7.08	ΣM=+2.30	V=-1.35	ΣM=-0.20	V=+0.12				
	0.10		10.00 0.50 11	33.00 36	1.20 0.50		27.50 50 19.50 1.30 1.50	21.50 18	0.80 0.50		3 4	0.30 0.60					
+6.90	V=-4.06	ΣM=+21.50	V=+12.70	ΣM=+67.30	V=-39.58	ΣM=-100.80	V=+60	ΣM=+38.20	V=-22.50	ΣM=-7	V=+4.12	ΣM=+0.90	V=-0.53				
	1	1.90 2.00	0.20		7.00 0.20 9	19.60 18	0.25 0.50	1.70	32 31	13.00 10.00	0.30 0.70	0.10 0.20	1.20 1.50				
-1	V=+0.60	ΣM=+3.70	V=-2.18	ΣM=-16.20	V=+9.52	ΣM=+36.85	V=-21.70	ΣM=-61.30	V=+36	ΣM=+22.40	V=-13.20	ΣM=-2.40	V=+1.41				
			0.30	1.00 2.00			3.60 4 0.05	12.00 1.50 10	0.50		16.30 1.70 18.20 1.10	4.40 0.45 5.30	0.40		0.30 0.30		
		ΣM=-0.30	V=+0.18	ΣM=+3	V=-1.77	ΣM=-7.65	V=+4.50	ΣM=+23	V=-13.50	ΣM=-37.30	V=+22	ΣM=+9.75	V=-5.75	ΣM=+0.60	V=-0.35		
						0.40 1.00			1.00 0.35 2	3.90 4.00	0.30 0.20	0.10	6.80 0.60 5.60 4.70	1.40 1.70	0.20 0.20		0.10 0.20
						ΣM=+1.40	V=-0.83	ΣM=-3.35	V=+1.97	ΣM=+7.40	V=-4.36	ΣM=-17.60	V=+10.30	ΣM=+2.70	V=-1.59	ΣM=+0.80	V=+0.18
											0.30	1.00 1.70	0.10 0.20		3.10 0.05 4.50	0.70 0.20 0.60	0.10
										ΣM=-0.30	V=+0.12	ΣM=+2.40	V=-0.98	ΣM=-8.15	V=+3.35	ΣM=+1.40	V=-0.57
													0.10 0.10	0.50 0.60	0.05		2.60 3.40 0.20
												ΣM=-0.20	V=+0.09	ΣM=+1.05	V=-0.47	ΣM=-6.20	V=+2.75

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ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER	RIAD SHAHIN	WIND ANALYSIS HARDY CROSS METHOD SHEARS
CHK'D BY	RIAD SHAHIN	
APP'D BY	Dr JACK NASSER	DATE: DECEMBER 1964 — SHEET No 37

Coefficientes of Δ's

Δ_1	Δ_2	Δ_3	Δ_4	Δ_5	Δ_6	Δ_7	Δ_8	Δ_9	Δ_{10}	Δ_{11}	Δ_{12}	Δ_{13}	Δ_{14}	Δ_{15}	Δ_{16}	Δ_{17}	Δ_{18}	Δ_{19}	Δ_{20}	Constant Vector x 10^4
+1390	-610	+266	-66.50	+16	-1.77	+0.88	0	0	0	0	0									60
-6.70	-8.70	-8.20	+190	-4380	+11.20	-2.95	+0.24	0	0	0	0									58.40
+197	-545	+1640	-853	+198	+7.40	+11.10	-2.60	+0.30	0	0	0									55.70
-49	+1.35	+4.26	+1330	-790	+172	-42.60	+11.20	-2.65	+0.30	0	0									53.30
+10.97	-31	+195	+1780	+1180	-625	+147	-35.30	+8.52	-2.65	0	0									50.70
-2.50	+6.70	-44.60	+177	-640	+920	-4.95	+117	-24.20	+8.35	-1.18	0									48.10
+0.31	-1.30	+11.30	-42.75	+151	-582	+735	-406	+90.50	-22.20	+530	-0.35	0								45.35
+0.06		-2.20	+10.60	-36	+115	-407	+590	-386	+68.50	-12.90	+3.20	-0.35	+0.12	0						42.45
			-17.60	+7.92	-25	+98	-812	+468	-232	+50.20	-11.30	+1.53	-0.47	0						39.55
				-1.47	+5.90	-81	+70.80	-266	+343	-174	+37	-6.35	+2.70	-0.18	0					36.40
					-1.18	+4.70	-17	+51.20	-172	+253	-125	+27	-8.35	+1.35	0					33.20
						-0.60	+412	-12	+36.70	-127	+189	-89	+20	-4.70	0					30.00
							-0.60	+2.30	-7.50	+27.50	-92	+124	-58	+12.70	-2.35	0				26.70
									+1.18	-6.30	+19.40	-58.50	+104	-39.70	+7.08	-1.35	+0.12			23.80
										+1.18	-4.06	+12.70	-39.50	+60	-22.50	+4.12	-0.53			19.90
											+0.60	-2.18	+9.52	-21.70	+36	-13.80	+1.41			16.40
												+0.18	-1.77	+4.50	-13.50	+28	+5.75	-0.35		12.80
														-0.83	+1.97	-4.36	+10.31	-1.59	+0.18	9.20
																+0.12	-0.98	+3.35	-0.57	5.55
																	+0.09	-0.47	+275	1.85

DATA

Coefficients of Δ's (cards 2–51); Constant Vectors (cards 52–54)

Card Nº	Col. 1.	Col. 2.	Col. 3.	Col. 4.	Col. 5.	Col. 6.	Col. 7.	Col. 8.
1	2̄00̄1							
2	5̄439000000	5̄361000000	5̄326600000	5̄266500000	5̄216000000	5̄117700000	5̄088000000	0̄——0
3	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0
4	0̄——0	0̄——0	0̄——0	0̄——0	5̄367000000	5̄387000000	5̄382000000	5̄319000000
5	5̄243800000	5̄211200000	5̄129500000	5̄024000000	0̄——0	0̄——0	0̄——0	0̄——0
6	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0
7	5̄319700000	5̄354500000	5̄416400000	5̄385300000	5̄319800000	5̄174000000	5̄211100000	5̄126000000
8	5̄030000000	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0
9	0̄——0	0̄——0	0̄——0	0̄——0	5̄249000000	5̄313500000	5̄142600000	5̄412700000
10	5̄379000000	5̄317200000	5̄242600000	5̄211200000	5̄126500000	5̄030000000	0̄——0	0̄——0
11	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0
12	5̄210900000	5̄231000000	5̄319500000	5̄378000000	5̄411800000	5̄362500000	5̄314700000	5̄235300000
13	5̄185200000	5̄126500000	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0
14	0̄——0	0̄——0	0̄——0	0̄——0	5̄125000000	5̄167000000	5̄244600000	5̄317700000
15	5̄364000000	5̄392000000	5̄349500000	5̄311700000	5̄224200000	5̄183500000	5̄111800000	0̄——0
16	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0
17	5̄031000000	5̄113000000	5̄211300000	5̄242780000	5̄315100000	5̄350200000	5̄373500000	5̄340600000
18	5̄290500000	5̄220500000	5̄153000000	5̄035000000	0̄——0	0̄——0	0̄——0	0̄——0
19	0̄——0	0̄——0	0̄——0	0̄——0	4̄960000000	0̄——0	5̄122000000	5̄210600000
20	5̄336000000	5̄311500000	5̄340700000	5̄359000000	5̄332600000	5̄268500000	5̄212900000	5̄132000000
21	5̄035000000	5̄012000000	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0
22	0̄——0	0̄——0	0̄——0	5̄217600000	5̄179200000	5̄225000000	5̄298000000	5̄331200000
23	5̄346800000	5̄323200000	5̄250200000	5̄211300000	5̄115300000	5̄047000000	0̄——0	0̄——0
24	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0
25	5̄114700000	5̄159000000	5̄221000000	5̄270800000	5̄326600000	5̄334300000	5̄317400000	5̄237000000
26	5̄183500000	5̄127000000	5̄018000000	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0
27	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	5̄111800000	5̄147000000	5̄217000000
28	5̄251200000	5̄317200000	5̄325300000	5̄312500000	5̄227000000	5̄183500000	5̄113500000	0̄——0
29	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0
30	0̄——0	0̄——0	5̄060000000	5̄141200000	5̄212000000	5̄236700000	5̄312700000	5̄318900000
31	5̄289000000	5̄220300000	5̄147000000	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0
32	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	5̄060000000
33	5̄123000000	5̄175000000	5̄227500000	5̄291000000	5̄313400000	5̄256800000	5̄212700000	5̄123500000
34	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0
35	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	5̄111800000	5̄163000000	5̄219400000
36	5̄258500000	5̄310400000	5̄239700000	5̄170800000	5̄113500000	5̄012000000	0̄——0	0̄——0
37	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0
38	0̄——0	0̄——0	5̄118000000	5̄140600000	5̄212700000	5̄239500000	5̄260000000	5̄222500000
39	5̄141200000	5̄053000000	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0
40	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	5̄040000000
41	5̄121800000	5̄195200000	5̄221700000	5̄236000000	5̄213200000	5̄114100000	0̄——0	0̄——0
42	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0
43	0̄——0	0̄——0	0̄——0	0̄——0	5̄018000000	5̄117700000	5̄145000000	5̄213500000
44	5̄222000000	5̄157500000	5̄035000000	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0
45	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0
46	0̄——0	0̄——0	5̄083000000	5̄119700000	5̄143600000	5̄210300000	5̄115900000	5̄018000000
47	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0
48	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0	0̄——0
49	5̄012000000	5̄098000000	5̄133500000	5̄057000000	0̄——0	0̄——0	0̄——0	0̄——0
50	0——0	0——0	0——0	0——0	0——0	0——0	0——0	0——0
51	0——0	0——0	0——0	0——0	0——0	4̄990000000	5̄047000000	5̄127500000
52	5̄660000000	5̄658400000	5̄655700000	5̄655300000	5̄650700000	5̄648100000	5̄645350000	5̄642450000
53	5̄639550000	5̄636400000	5̄633200000	5̄630000000	5̄626700000	5̄623300000	5̄619900000	5̄616400000
54	5̄612800000	5̄582000000	5̄555000000	5̄518500000				

CONSTANT VECTOR
5660000000
5658400000
5655700000
5655300000
5650700000
5648100000
5645350000
5642450000
5639550000
5636400000
5633200000
5630000000
5626700000
5623300000
5619900000
5616400000
5612800000
5592000000
5555500000
5518500000
SOLUTION OF SYSTEM FOR ABOVE LISTED VECTOR
5414460775
5427975187
5412043157
5379877684
5418982066
5458285045
5510403778
5513978150
5516450226
5520029694
5520251165
5518738491
5516450883
5513794960
5514996205
5517002073
5519346969
5518450215
5522981723
5510051232

№ 5828

1/4

Joint	Member	Δ1 = 0.14440	Δ2 = 0.2797	Δ3 = 0.1204	Δ4 = 0.0798	Δ5 = 0.1898	Δ7 = 1.040	Δ8 = 1.3978	Δ9 = 1.645	Δ10 = 2.0029	Δ11 = 2.0251	Δ12 = 1.8738	Δ13 = 1.6455	Δ14 = 1.3794	Δ15 = 1.4946	Δ16 = 1.7	Δ17 = 1.9346	Δ18 = 1.845	Δ19 = 2.2982	Δ20 = 1.005
0	S	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]												
1	S I R	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]												
2	S I R	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]										
3	S I R	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]										
4	S I R	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]									
5	S I R	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]									
6	S I R	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]							
7	S I R	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]							
8	S I R			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					
9	S I R					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					
10	S I R						[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
11	S I R						[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
12	S I R						[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			
13	S I R							[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
14	S I R									[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
15	S I R											[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	S I R												[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

12			13			14			15			16			17			18			19			20			2a			19a			18a			17a			16a			15a			14
S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	L	R	-	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L

2/4

-2.40 +5.90 -3.60 -2.70 +3.40 -0.70 -1.10 +1.10 — +0.85 +0.20 -1.65 -1.20 +3.10 +2.40 -1.70 -2.00 +7.10 +3.90 -7.60

3/4

190				180				170				160				150				140				130				120				110				100				90				80				70				
S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S

4/4

13a				12a				11a				10a				9a				8a				7a				6a				5a				4a				3a				2a				1a				0
S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S

ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDIND

Comparison of Approximate and Exact Methods

COMPUTER : RIAD SHAHIN	WIND ANALYSIS HARDY CROSS METHOD FINAL MOMENTS
CHK'D BY : RIAD SHAHIN	
APP'D BY : DR. JACK NASSER	DATE: DECEMBER 1964 SHEET No. 41

CASE B

Physical Constants

Joint	K_c I	K_c S	K_g, R	ΣK	Distribution factors I	R	S
20	0.97	0	7.40	8.37	0.12	0.88	0
19	0.97	0.97	7.40	9.34	0.11	0.78	0.11
18	3.33	0.97	7.40	11.70	0.28	0.63	0.09
17	11.30	3.33	7.40	21.93	0.51	0.34	0.15
16	20.30	11.30	12.80	44.30	0.46	0.29	0.25
15	33.80	20.30	12.80	66.90	0.51	0.19	0.30
14	51.50	33.80	12.80	98.10	0.53	0.13	0.34
13	75.00	51.50	12.80	139.30	0.54	0.09	0.37
12	105.00	75.00	20.30	200.30	0.53	0.10	0.37
11	162.50	105.00	20.30	287.30	0.56	0.08	0.36
10	210.00	162.00	20.30	392.30	0.54	0.05	0.41
9	270.00	210.00	20.30	496.30	0.54	0.04	0.42
8	373.00	270.00	30.50	669.50	0.55	0.05	0.40
7	460.00	373.00	30.50	863.50	0.53	0.04	0.43
6	550.00	460.00	30.50	1040.50	0.53	0.03	0.44
5	710.00	550.00	30.50	1280.50	0.53	0.03	0.43
4	980.00	710.00	43.20	1723.20	0.57	0.03	0.40
3	980.00	980.00	43.20	2003.20	0.49	0.02	0.49
2	680.00	980.00	43.20	1703.20	0.40	0.03	0.57
1	740.00	680.00	43.20	1463.20	0.51	0.03	0.46

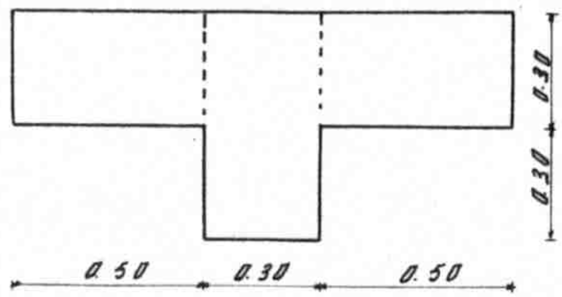
Joint a	K_{g2}	K_c S	K_{g1} L	K_{g2} R	K_c I	ΣK	Distribution factors S	L	R	I
20	4.80	0	7.40	7.20	0.97	15.57	0	0.47	0.46	0.07
19	4.80	0.97	7.40	7.20	1.92	21.49	0.04	0.34	0.33	0.09
18	4.80	1.92	7.40	7.20	5.25	21.77	0.09	0.34	0.33	0.24
17	4.80	5.25	7.40	7.20	11.30	31.15	0.17	0.24	0.23	0.36
16	8.30	11.30	12.80	12.45	20.30	56.85	0.20	0.22	0.22	0.36
15	8.30	20.30	12.80	12.45	33.80	79.25	0.35	0.16	0.16	0.43
14	8.30	33.80	12.80	12.45	63.00	122.05	0.28	0.11	0.10	0.51
13	8.30	63.00	12.80	12.45	89.00	176.25	0.36	0.07	0.07	0.50
12	13.10	89.00	20.30	19.65	123.00	251.95	0.36	0.08	0.08	0.49
11	13.10	123.00	20.30	19.65	162.00	324.95	0.38	0.06	0.06	0.50
10	13.10	162.00	20.30	19.65	238.00	439.95	0.37	0.05	0.04	0.54
9	13.10	162.00	20.30	19.65	298.00	570.95	0.41	0.04	0.03	0.52
8	19.60	298.00	30.50	29.40	412.00	764.90	0.38	0.04	0.04	0.54
7	19.60	412.00	30.50	29.40	500.00	971.90	0.42	0.03	0.03	0.52
6	19.60	500.00	30.50	29.40	600.00	1159.90	0.43	0.03	0.02	0.52
5	19.60	600.00	30.50	29.40	770.00	1415.90	0.42	0.02	0.02	0.54
4	28.00	770.00	43.00	42.00	980.00	1821.20	0.42	0.02	0.02	0.54
3	28.00	980.00	43.00	42.00	980.00	2045.20	0.48	0.02	0.02	0.48
2	28.00	980.00	43.00	42.00	680.00	1745.20	0.56	0.03	0.02	0.39
1	28.00	680.00	43.00	42.00	740.00	1505.20	0.45	0.03	0.03	0.49

__N.B.__ No analysis is conducted for this case for reasons which were discussed in chapter 7 (Text.)

CASE C

I Values For Beams

1. Sample Calculation



	A (m)	S_x (m^3)	I (m^4)
	$b \times d$	$\frac{bd^2}{2} = bd\left(\frac{d}{2}\right)$	$\frac{bd^3}{3} = \left(\frac{bd^2}{2}\right)\left(\frac{2}{3}d\right)$
	$0.30 \times 0.60 = 0.18$	$0.18 \times 0.30 = 0.054$	$0.054 \times \frac{2}{3} \times 0.60 = 0.0216$
	$1.00 \times 0.30 = 0.30$	$0.30 \times 0.15 = 0.045$	$0.045 \times \frac{2}{3} \times 0.30 = 0.0090$
Total	0.48	0.099	0.0306

$$x_g = \frac{\Sigma S_x}{\Sigma A} = \frac{0.099}{0.48} = 0.206$$

$$\Sigma A \bar{x}_g^2 = 0.48 \times 0206 = 0.48 \times 0.043 = 0.0206 \ m^4$$

$$I_{N.A} = 0.0306 - 0.0206 = 0.0100$$

(1) $K_{g1} = \frac{0.0100}{4.20} = 0.0024$ (2) K_{g1} (Rel) = 24

(1) $K_{g2} = \frac{0.0100}{6.50} = 0.00154$ (2) K_{g2} (Rel) = 15.40

N.B

(1) - K_{g1} represents the stiffness of the exterior beam whereas K_{g2} represents the stiffness of the central beam

(2) The relative values of K are multiplied by a factor of 10^4

2. Tabulated Results

Floor	Dimensions b x d (m x m)	Overhangs (m)	A (m^2)	Sx (m^3)	I (m^4)	xg (m)	$A \cdot \overline{x}_g^2$ (m^4)	$I_{N.A.}$ m^4	Kg_1		Kg_2	
									Abs.	Rel.	Abs.	Rel.
20–17	0.30 x 0.60	1.00	0.48	0.099	0.0306	0.206	0.0206	0.0100	0.0024	24.00	0.00154	15.40
16–13	0.30 x 0.70	"	0.51	0.1182	0.0432	0.232	0.0275	0.0157	0.00373	37.30	0.00242	24.20
12–9	0.30 x 0.80	"	0.54	0.1410	0.0602	0.261	0.0368	0.0234	0.00558	55.80	0.00360	36.00
8–5	0.30 x 0.90	"	0.57	0.1660	0.0816	0.291	0.0484	0.0332	0.0079	79.00	0.00510	51.00
4–1	0.30 x 1.00	"	0.60	0.1950	0.1090	0.325	0.0636	0.0454	0.0108	108.00	0.00700	70.00

K Values For Columns

The column sizes will be changed every four floors and will be taken as

50 x 40, 50x60, 50x80, 50x 100, 50 x 120 cms

Story	b/12 (m)	d^3	bd^3	l (m)	K = I/l	K (Rel)
20-16	0.0416	0.064	0.00262	3.40	0.00077	7.70
16-12	"	0.216	0.00900	"	0.00264	26.40
12-8	"	0.512	0.0213	"	0.00625	62.50
8-4	"	1.00	0.0416	"	0.01220	122.00
4-2	"	1.728	0.0720	"	0.02110	211.00
2-1	"	"	"	4.90	0.01470	147.00
1-0	"	"	"	4.50	0.01600	160.00

Physical Constants Assuming No Hinges In Columns

Joint	K_{g_1}	K_c		ΣK	Distribution Factors			F.E.M. (T-m)	
		I	S					$6/l$	$-6EK\Delta/l$
20	24	7.70	0	31.70	0.24	0.76	0	1.76	- 13.50
19, 18, 17	24	7.70	7.70	39.40	0.20	0.60	0.20	"	- "
16	37.30	26.40	"	71.40	0.37	0.52	0.11	"	- 46.50
15, 14, 13	"	"	26.40	90.10	0.29	0.42	0.29	"	- "
12	55.80	62.50	"	144.70	0.43	0.39	0.18	"	- 110.00
11, 10, 9	"	"	62.50	180.80	0.34	0.32	0.34	"	- "
8	79.00	122.00	"	263.50	0.46	0.30	0.24	"	- 214.00
7, 6, 5	"	"	122	323.00	0.38	0.24	0.38	"	- "
4	108.00	211.00	"	441.00	0.48	0.24	0.28	"	- 370.00
3	"	"	211	530.00	0.40	0.20	0.40	"	- "
2	"	147.00	"	466.00	0.32	0.23	0.45	1.22	- 179.00
1	"	160.00	147	415.00	0.39	0.26	0.35	1.33	- 213.00

<u>N.B</u> The value of $E\Delta$ is taken as 10^4, and its value is omitted becuase the relative K's have been aleady multiplied by 10^4

Joint (a)	Kg2	Kc	Kg1	Kg2 (Mod.)	Kc	ΣK	Distribution Factors			
		S	L	R	I		S	L	R	I
20a	15.40	0	24	23.00	7.70	54.70	0	0.44	0.42	0.14
19, 18, 17	"	7.70	"	"	"	62.40	0.12	0.39	0.37	0.12
16	24.20	"	37.30	36.20	26.40	107.60	0.07	0.35	0.34	0.24
15, 14, 13	"	26.40	"	"	"	126.30	0.21	0.30	0.28	0.21
12	36.00	"	55.80	53.90	62.50	198.60	0.13	0.28	0.27	0.32
11, 10, 9	"	62.50	"	"	"	234.70	0.27	0.24	0.23	0.26
8	51.00	"	79.00	76.20	122.00	339.70	0.18	0.23	0.23	0.36
7, 6, 5	"	122.00	"	"	"	339.20	0.30	0.20	0.20	0.30
4	70.00	"	108.00	105.00	211.00	546.00	0.22	0.20	0.19	0.39
3	"	211.00	"	"	"	635.00	0.33	0.17	0.17	0.33
2	"	"	"	"	147.00	571.00	0.37	0.19	0.18	0.26
1	"	147.00	"	"	160.00	520.00	0.28	0.21	0.20	0.31

Physical Constants Assuming Hinges At Mid-Height of Columns

(Excluding Two Top Most Columns)

Joint	Kc (Mod) I	Kg R	Kc S	Σ K	Distribution Factors I	R	S	F E M (T-m)
18	11.50	24.00	7.70	43.20	0.26	0.56	0.18	- 27
17	"	"	"		"	"	"	- "
16	39.50	37.30	"	84.50	0.47	0.44	0.09	- 93
15	"	"	26.40	103.20	0.38	0.36	0.26	- "
14	"	"	"		"	"	"	- "
13	"	"	"		"	"	"	- "
12	93.30	55.80	"	175.50	0.53	0.32	0.15	- 220
11	"	"	62.50	211.60	0.44	0.27	0.29	- "
10	"	"	"		"	"	"	- "
9	"	"	"		"	"	"	- "
8	183.00	79.00	"	324.50	0.56	0.25	0.19	- 428
7	"	"	122.00	384.00	0.47	0.21	0.32	- "
6	"	"	"		"	"	"	- "
5	"	"	"		"	"	"	- "
4	315.00	108.00	"	545.00	0.58	0.20	0.22	- 740
3	"	"	211.00	634.00	0.50	0.17	0.33	- "
2	220.00	"	"	539.00	0.41	0.20	0.39	- 358
1	240.00	"	147.00	495.00	0.48	0.22	0.30	- 426

N.B $(FEM)_2 = -3EK_2 \frac{\Delta}{\ell_2}$, $K_2 = \frac{I}{\ell_1/2} = \frac{2I}{\ell_1} = 2K$

$(F.E.M)_2 = -3E \times 2K \times \frac{\Delta}{\ell_1} \times 2 = -\frac{12EK\Delta}{\ell_1} = -\frac{2EK\Delta}{\ell}$

Joint (a)	K-Values				ΣK	Distribution Factors			
	S	L	R	I		S	L	R	I
18, 17	7.70	24	23	11.50	66.20	0.12	0.36	0.35	0.17
16	"	37.30	36.20	39.50	120.70	0.06	0.31	0.30	0.33
15, 14, 13	26.40	"	"	"	139.40	0.19	0.27	0.26	0.28
12	"	55.80	53.90	93.30	229.40	0.12	0.24	0.24	0.40
11, 10, 9	62.50	"	"	"	265.50	0.24	0.21	0.20	0.35
8	"	79.00	76.20	183.00	400.70	0.16	0.20	0.19	0.45
7, 6, 5	122.00	"	"	"	460.20	0.26	0.17	0.17	0.40
4	"	108.00	105.00	315.00	650.00	0.19	0.17	0.16	0.48
3	211.00	"	"	"	739.00	0.28	0.15	0.15	0.42
2	"	"	"	220.00	644.00	0.33	0.17	0.16	0.34
1	147.00	"	"	240.00	600.00	0.25	0.18	0.17	0.40

Physical Constants At Top Most Floors When Going One Floor Lower

Joint	Kc	Kg	ΣK	Distribution Factors		
	I	R		I	R	S
19, 18, 17	7.70	24	31.70	0.24	0.76	0
16	26.40	37.30	63.70	0.42	0.58	"
15, 14, 13	"	"	"	"	"	"
12	62.50	55.80	118.30	0.53	0.47	"
11, 10, 9	"	"	"	"	"	"
8	122.00	79.00	201.00	0.61	0.39	"
7, 6, 5	"	"	"	"	"	"
4	211.00	108.00	319.00	0.66	0.34	"
3	"	"	"	"	"	"

Joint (a)	Kc	Kg1	Kg2 (Mod)	Kc	ΣK	Distribution Factors			
	S	L	R	I		S	L	R	I
19, 18, 17	0	24.00	23.00	7.70	54.70	0	0.44	0.42	0.14
16	"	37.30	36.20	26.40	99.90	"	0.37	0.36	0.27
15, 14, 13	"	"	"	"	"	"	"	"	"
12	"	55.80	53.90	62.50	172.20	"	0.32	0.32	0.36
11, 10, 9	"	"	"	"	"	"	"	"	"
8	"	79.00	76.20	122.00	277.20	"	0.29	0.27	0.44
7, 6, 5	"	"	"	"	"	"	"	"	"
4	"	108.00	105.00	211.00	424.00	"	0.25	0.25	0.50
3	"	"	"	"	"	"	"	"	"

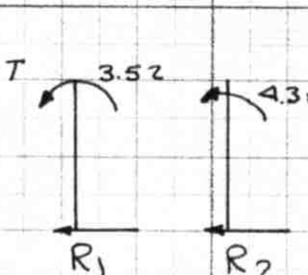
JOINT	18			19			20		20a			19a				18a			
MEMBER	I	R	S	I	R	S	I	R	L	R	I	S	L	R	I	S	L	R	I
DIST. FACTOR	0.26	0.56	0.18	0.20	0.60	0.20	0.24	0.76	0.44	0.42	0.14	0.12	0.39	0.37	0.12	0.12	0.36	0.35	0.17
Influence of Δ 20			+1.40	+2.70	+8.10	-13.50 +2.70	-13.50 +1.40	+3.00	+5.90	+5.70	-13.50 +1.90	-13.50 +1.00	+4.10						
					+1.70	+1.10	+2.20	+6.90	+3.50		+0.50	+1.00	+8.30	+8.10	+1.00	+0.50			
			-0.30	-0.60	-1.70	-0.50	-0.30	-0.90	-1.80	-1.70	-0.50	-0.30	-0.90						
	-0.30	-0.60	-0.20	-0.10	+0.30	+0.20	+0.30	+0.90	+0.50		0	+0.0	+0.50	+0.50	+0.0	0	-0.30		
	-0.30	-0.60	+0.90	-0.10	-0.20	-0.10		-0.10 +0.10	-0.20	-0.20	-0.10	0	-0.10 +0.10				-0.10	-0.10	
				+1.90	+8.20	-10.10			+7.90	+3.80	-11.70								
							-9.90	+9.90											
												-11.70	+7.00	+3.60	+1.10	+0.50	-0.40	-0.10	0
Influence of Δ 19	+3.50	+7.60	-13.50 +2.40	-13.50 +1.20	+2.70						+0.80	+1.60	+5.30	+5.00	-13.50 +1.60	-13.50 +0.80	+3.80		
		+1.60	+1.00	+1.90	+5.80	+1.90	+1.00						+2.90		+0.60	+1.10	+3.20	+3.10	+1.50
	-0.70	-1.50	-0.40	-0.020	-0.70						-0.20	-0.40	-1.40	-1.30	-0.40	-0.20	-0.80		
								-0.20	0.30	0.20	-0.10								
		+0.20				-0.10	-0.20	-0.60	-0.30						0	+0.10	+0.40	+0.40	+0.10
			+0.10	+0.20	+0.60	+0.20	+0.10		+0.10	+0.10	+0.10		+0.30						
	-0.10	-0.20		-10.40	+8.40	+2.50		-0.10				-0.10	-0.10	-0.10			-0.10 +0.10		
	+2.70	+7.20	-10.40				+0.90	-0.90	-0.50	-0.10	+0.60	+1.10	+7.00	+3.60	-11.70	-11.70	+6.60	+3.50	+1.60
Influence of Δ 18	-27.00 +7.00	+15.10	+4.90	+2.50													+7.60		-27.00
	-0.90	+3.50 -2.00	-0.60	-0.30											+1.20	+2.30	+7.00	+6.80	+3.30
																	-1.00		
			-0.20	-0.50	-1.30	-0.40	-0.20						-0.70						
		+0.20													0	+0.40	+0.40	+0.40	+0.10
					-0.10			+0.20											
					+0.10							-0.10	+0.20	0.20					
	-20.90	+16.80	+4.10	+11.70	-1.30	-0.40	-0.20	+020				+0.10	-0.90	-0.20	+1.20	+2.40	+14.00	+7.20	-23.60
Final Moments	-0.03					-0.98	-0.96	+0.96	+0.76	+0.37	-1.13	-1.13							0
	+0.71					+0.53	+0.24	-0.24	-0.13	-.03	+0.16	+0.29							+0.47
	-4.20					-0.08	-0.04	+0.04	0	0	0	-0.02							-4.77
	-3.52					-0.53	-0.76	+0.76	+0.63	+0.34	-0.97	-0.86							-4.30

Checking Results

$R_1 + R_2 = \frac{3.52 + 4.30}{1.70} = \frac{7.82}{1.70} = 4.60\,T$

$\Sigma F_x = 2(R_1 + R_2) - 9.20 = 0.00$

$\therefore$ O.K.



ANALYSIS OF THE EFFECT OF WIND ON A HIGH
REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER : RIAD SHAHIN

CHK'D BY : RIAD SHAHIN

APP'D BY : Dr JACK NASSER

WIND ANALYSIS

HARDY CROSS METHOD

DATE, DECEMBER 1964 | SHEET No 52 /

20-19-18 Floors

1. *Shears*

$$V_{18} = -\frac{2}{1.70}(-30+0) = -\frac{2}{1.70}(-0.30) = +0.35 = +0.35 \times \frac{\Delta 20}{10^4}$$

$$V_{19} = -\frac{2}{3.40}(+0.90+1.90+0.50+1.10) = -\frac{2}{3.40}(+3.40) = -2 = -2 \times \frac{\Delta 20}{10^4}$$

$$V_{20}' = \frac{-2}{3.40}(-10.10-9.90-11.70-11.70) = -\frac{2}{3.40}(-43.40) = +25.60 = +25.60 \times \frac{\Delta 20}{10^4}$$

$$V_{18} = \frac{-2}{1.70}(+2.70+1.60) = \frac{-2}{1.70}(+4.30) = -5.06 = -5.06 \times \frac{\Delta 19}{10^4}$$

$$V_{19} = \frac{-2}{3.40}(-10.40-10.40-11.70-11.70) = \frac{-2}{3.40}(-44.20) = +26 = +26 \times \frac{\Delta 19}{10^4}$$

$$V_{20} = \frac{-2}{3.40}(+2.00+0.90+1.10+0.60) = \frac{-2}{3.40}(+4.60) = -2.70 = -2.70 \times \frac{\Delta 19}{10^4}$$

$$V_{18} = \frac{-2}{1.70}(-20.90-23.60) = \frac{-2}{1.70}(-44.50) = +52.30 = 52.30 \times \frac{\Delta 18}{10^4}$$

$$V_{19} = \frac{-2}{3.40}(+4.10+1.70+2.40+1.20) = \frac{-2}{3.40}(+9.40) = -5.52 = -5.52 \times \frac{\Delta 18}{10^4}$$

$$V_{20} = \frac{-2}{3.40}(-0.40-0.20-0.10) = \frac{-2}{3.40}(-0.70) = +0.41 = +0.41 \times \frac{\Delta 18}{10^4}$$

2. *Δ's*

$$+0.35\,\Delta_{20} - 5.06\,\Delta_{19} + 52.30\,\Delta_{18} = 9.20 \times 10^4$$

$$-2\,\Delta_{20} + 26\,\Delta_{19} - 5.52\,\Delta_{18} = 5.55 \times 10^4$$

$$+25.60\,\Delta_{20} - 2.70\,\Delta_{19} + 0.41\,\Delta_{18} = 1.85 \times 10^4$$

$$\Delta_{18} = 0.175 \times 10^4 - 0.00665\,\Delta_{20} + 0.0962\,\Delta_{19}$$

$$\Delta_{19} = 0.213 \times 10^4 + 0.077\,\Delta_{20} + 0.213\,\Delta_{18}$$

$$\Delta_{20} = 0.0722 \times 10^4 + 0.105\,\Delta_{19} - 0.016\,\Delta_{18}$$

Let $\Delta_{19} = 20 = 0$

$\Delta_{18} = 0.17 \times 10^4$

$\Delta_{19} = 0.213 \times 10^4 + 0 + 0.213 \times 0.175 \times 10^4 = 10^4(0.213 + 0.037) = 0.250 \times 10^4$

$\Delta_{20} = 0.0722 + 0.105 \times 0.250 - 0.016 \times 1.75 = 0.0722 + 0.0262 - 0.0028 = 0.0956$

$\Delta_{18} = 0.175 - 0.00665 \times 0.0956 + 0.0962 \times 0.25 = 0.175 - 0.000635 + 0.024 = 0.198$

$\Delta_{19} = 0.213 + 0.077 \times 0.956 + 0.213 \times 0.198 = 0.213 + 0.0073 + 0.0422 = 0.26$

$\Delta_{20} = 0.0722 + 0.105 \times 0.26 - 0.016 \times 0.198 = 0.0722 + 0.0272 - 0.0032 = 0.0962$

$\Delta_{18} = 0.175 - 0.00665 \times 0.0962 + 0.0962 \times 0.26 = 0.175 + 0.025 = 0.200$

$\Delta_{19} = 0.213 + 0.077 \times 0.0962 + 0.213 \times 0.200 = 0.213 + 0.0074 + 0.0430 = 0.263$

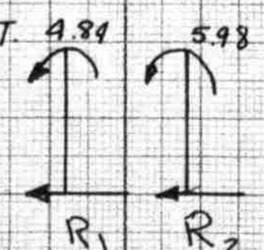
$\Delta_{20} = 0.0722 + 0.105 \times 0263 - 0.016 \times 0.200 = 0.0722 + 0.028 - 0.0032 = 0.097$

N. B Becuase 10^4 is always a common factor, it is ommitted tentatively

JOINT	17			18			19		19a			18a				17a			
MEMBER	I	R	S	I	R	S	I	R	L	R	I	S	L	R	I	S	L	R	I
DIST. FACTOR	0.26	0.56	0.18	0.20	0.60	0.20	0.24	0.76	0.44	0.42	0.14	0.12	0.39	0.37	0.12	0.12	0.36	0.35	0.17
Moment of Above Floor								-0.53	-0.86										
								+0.19	+0.38	+0.36	+0.12	+0.06							
						+0.04	+0.08	+0.26	+0.13										
								-0.03	-0.06	-0.05	-0.02	-0.01							
					-0.01							-0.01	-0.02	-0.01	-0.01				
					-0.02	-0.02	+0.01	+0.02	+0.45	+0.31	+0.10								
												+0.04	-0.02	-0.01	-0.01				
				0	-0.03	+0.03	+0.09	+0.44											
Final Moments	-0.080					-2.53	-2.47	+2.47	+1.97	+0.95	-2.92	-2.92							0
	+1.14					+0.84	+0.38	-0.36	-0.21	-0.03	+0.24	+0.47							+0.68
	-5.90					-0.1	-0.06	+0.06	-0	0	0	-0.03							-6.66
	-4.84					-1.80	-2.15	+2.15	+1.76	+0.92	-2.68	-2.48							-5.98

Checking Results

$R_1 + R_2 = \frac{4.84+5.98}{2} = 2.42+2.99 = 5.41T.$



$\Sigma Fx = 12.80 - 5.41 \times 2 =$

$12.80 - 10.82 = 0.02$

∴ O.K

ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER :	RIAD SHAHIN	WIND ANALYSIS
CHK'D BY :	RIAD SHAHIN	HARDY CROSS METHOD
APP'D BY :	Dr. JACK NASSER	DATE: DECEMBER 1964 SHEET No 55 /

19-18-17 Floors

1 Shears (Same as previous case)

2 Effect of 20^{th} Floor

$$V_{17} = 0$$

$$V_{18} = -\frac{2}{3.40}(0-0.01) = \frac{0.02}{3.40} = 0.006$$

$$V_{19} = -\frac{2}{3.40}(+0.03+0.09+0.10+0.04) = \frac{-2}{3.40} \times 0.26 = \frac{-0.52}{3.40} = -0.153$$

3 Δ's

$$+0.35\,\Delta_{19} - 5.06\,\Delta_{18} + 52.30\,\Delta_{17} = (12+0)\,10^4$$

$$-2\,\Delta_{19} + 26\,\Delta_{18} - 5.52\,\Delta_{17} = (9.20+0.006)\,10^4$$

$$+25.60\,\Delta_{19} - 870\,\Delta_{18} + 0.41\,\Delta_{17} = (5.55-0.15)\,10^4$$

$$\Delta_{17} = 0.244 \times 10^4 - 0.00665\,\Delta_{19} + 0.0962\,\Delta_{18}$$

$$\Delta_{18} = 0.344 \times 10^4 + 0.077\,\Delta_{19} + 0.213\,\Delta_{17}$$

$$\Delta_{19} = 0.211 \times 10^4 + 0.105\,\Delta_{18} - 0.016\,\Delta_{17}$$

Let $\Delta_{19} = \Delta_{18} = 0$

$\Delta_{17} = 0.244 \times 10^4$

$$\Delta_{18} = 0.344 + 0.077 \times 0.213 \times 0.244 = 0.344 + 0.052 = 0.396$$

$$\Delta_{19} = 0.211 + 0.105 \times 0.396 - 0.016 \times 0.244 = 0.211 + 0.042 - 0.004 = 0.249$$

$$\Delta_{17} = 0.244 - 0.00665 \times 0.249 + 0.0962 \times 0.396 = 0.244 - 0.0017 + 0.038 = 0.280$$

$$\Delta_{18} = 0.344 + 0.077 \times 0.249 + 0.213 \times 0.280 = 0.344 + 0.019 + 0.060 = 0.423$$

$$\Delta_{19} = 0.214 + 0.105 \times 0.423 - 0.016 \times 0.280 = 0.217 + 0.044 - 0.005 = 0.250$$

$$\Delta_{17} = 0.244 - 0.00665 \times 0.250 + 0.0962 \times 0.423 = 0.244 - 0.0017 + 0.041 = 0.283$$

$$\Delta_{18} = 0.344 + 0.077 \times 0.250 + 0.213 \times 0.283 = 0.344 + 0.019 + 0.060 = 0.483$$

$$\Delta_{19} = 0.210 + 0.105 \times 0.423 - 0.016 \times 0.283 = 0.210 + 0.045 - 0.005 = 0.250$$

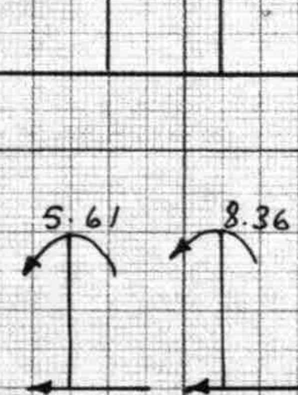
JOINT	16			17			18		18a			17a				16a			
MEMBER	I	R	S	I	R	S	I	R	L	R	I	S	L	R	I	S	L	R	I
DIST FACTOR	0.47	0.44	0.09	0.20	0.60	0.20	0.24	0.76	0.44	0.42	0.14	0.12	0.39	0.37	0.12	0.06	0.31	0.30	0.33
Influence of Δ 18						-13.50	-13.50				-13.50	-13.50							
			+1.40	+2.70	+8.10	+2.70	+1.40	+3.00	+5.90	+5.70	+1.90	+1.00	+4.10						
					+1.70	+1.10	+2.20	+6.90	+3.50		+0.50	+1.00	+3.20	+3.10	+1.00	+0.50			
			-0.30	-0.60	-1.70	-0.30	-0.30	-0.90	-1.80	-1.70	-0.50	-0.30	-0.90						
	-0.50	-0.50	-0.10	0	+0.30	+0.20	+0.30	+0.90	+0.50		0	+0.10	+0.50	+0.50	+0.10	0	-0.30		
				-0.10	-0.30	-0.10	0	-0.10	-0.20	-0.20	-0.10	0	-0.20					-0.10	-0.10
	-0.50	-0.50	+1.00					+0.10					+0.10	+0.10					
				+2.00	+8.10	-10.0			+7.90	+3.80	-11.70								
							-9.90	+9.90				-11.70	+6.90	+3.70	+1.10	+0.50	-0.30	-0.10	-0.10
Influence of Δ 17			-13.50	-13.50											-13.50	-13.50			
	+6.30	+5.90	+1.30	+0.70	+2.70						+0.80	+1.60	+5.30	+5.00	+1.60	+0.80	+3.00		
															+0.30	+0.60	+3.00	+2.90	+3.20
		+1.50	+1	+2	+6.10	+2	+1						+3.10						
	-1.20	-1.10	-0.20	-0.10	-0.70	-0.10	-0.20	-0.80	-0.40		-0.20	-0.40	-1.30	-1.30	-0.40	-0.20	-0.60		
		+0.10	+0.10	+0.20	-0.50	+0.20	+0.10		-0.10	-0.10	0		+0.30		0	+0.10	+0.20	+0.20	+0.30
	-0.10	-0.10	0					-0.10	-0.50	-0.10	+0.60		-0.10	-0.10	-0.10	-12.20	+5.60	13.10	+3.50
	+5.00	+6.30	-11.30	-10.70	+8.60	+2.10	+0.90	-0.90				+1.20	+7.30	+3.60	-12.10				
Influence of Δ 16	-93																		-93
	+43.60	+41.00	+8.40	+4.20													+20.50		
		+11.30													+2.20	+4.30	+22.50	+21.70	+24
	-5.30	-5.00	-1.00	-0.50													-2.50		
		+0.40	-0.40	-0.70	-2.20	-0.80	-0.40						-1.10		0	+0.10	+0.80	+0.80	+0.80
	0	0	0		-0.30		+0.10	+0.30	+0.20		0	-0.10	-0.50	-0.40	-0.10				
					+0.30											+4.40	+41.30	+22.50	-68.20
	-54.70	+47.70	+7.00						-0.10	-0.0		-0.10	-1.60	-0.40	+2.10				
				+3.00	-2.20	-0.80	-0.30	+0.30											
									+0.10	-0.10	0								
Influence of Moment of Above Floor							-1.80			-2.48									
								+0.55	+1.09	+1.04	+0.35	+0.18							
						+0.15	+0.30	+0.95	+0.48										
								-0.10	-0.21	-0.20	-0.07	-0.04							
					-0.03						-0.01	-0.02	-0.05	-0.05	-0.02	-0.01			
			-0.01	-0.02	-0.08	-0.02	-0.01						0.04				0.01		
			-0.01			+0.02	+0.03	+0.07	+0.04			+0.01	+0.01	+0.01	+0.01				
				0	-0.02	0			-0.02	-0.01	0	+0.13	-0.08	-0.04	-0.01	-0.01	+0.01	0	0
							+0.32	+1.48											
				-0.02	-0.13	+0.15			+1.38	+0.83	+0.27								
Final Moments	-0.20					-4.00	-4.93	+4.93	+3.15	+1.51	-4.66	-4.66							-0.04
	+2.82					+1.19	+0.51	-0.51	-0.28	-0.06	+0.34	+0.68							+1.98
	-8.23					-0.12	-0.05	+0.05	+0.02	-0.02	0	-0.02							-10.30
	-5.61					-2.93	-4.47	+4.47	+2.89	+1.43	-4.32	-4.00							-8.36

Checking Results:

$R_1 + R_2 = \frac{5.61 + 8.36}{1.70} = \frac{13.97}{1.70} = 8.20$

$\Sigma F_x = 16.40 - 2 \times 8.20 = 0$

∴ O.K.



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER: RIAD SHAHIN	WIND ANALYSIS	
CHK'D BY: RIAD SHAHIN	HARDY CROSS METHOD	
APP'D BY: DR. JACK NASSER	DATE: DECEMBER 1964	SHEET Nº 57 /

18-17-16 Floors

1 Shears

$$V_{16} = \frac{-2}{1.70}(.0.50-0.10) = \frac{-2}{1.70}(-0.60) = +0.703 = +0.703 \times \frac{\Delta_{18}}{10^4}$$

$$V_{17} = \frac{-2}{3.40}(+1.00+2.00+0.50+1.10) = \frac{-2}{3.40}(+4.60) = -2.70 = -2.70\frac{\Delta_{18}}{10^4}$$

$$V_{18} = \frac{-2}{3.40}(-10.10-9.90-11.70-11.70) = \frac{-2}{3.40}(-43.40) = 25.50 = 25.50\frac{\Delta_{18}}{10^4}$$

$$V_{16} = \frac{-2}{1.70}(+5.00+3.50) = \frac{-2}{1.70}(+8.50) = -10 = -10\frac{\Delta_{17}}{10^4}$$

$$V_{17} = \frac{-2}{3.40}(-11.30-10.70-12.20-12.10) = \frac{-2}{3.40}(-46.30) = +27.20 = 27.20\frac{\Delta_{17}}{10^4}$$

$$V_{18} = \frac{-2}{3.40}(+2.10+0.90+1.20+0.60) = \frac{-2}{3.40}(+4.80) = -2.82 = -2.82\frac{\Delta_{17}}{10^4}$$

$$V_{16} = \frac{-2}{1.70}(-54.70-68.20) = \frac{-2}{1.70}(-122.90) = +144 = 144\frac{\Delta_{16}}{10^4}$$

$$V_{17} = \frac{-2}{3.40}(+7.00+3.00+4.40+2.10) = \frac{-2}{3.40}(+16.50) = -9.70 = -9.70\frac{\Delta_{16}}{10^4}$$

$$V_{18} = \frac{-2}{3.40}(-0.80-0.30-0.10+0) = \frac{-2}{3.40}(-1.20) = 0.703 = +0.703\frac{\Delta_{16}}{10^4}$$

2 Effect of the 19th floor

$$V_{16} = \frac{-2}{1.70}(0+0) = 0$$

$$V_{17} = \frac{-2}{3.40}(-0.01-0.02-0.01-0.01) = \frac{-2}{3.40}(-0.05) = +0.03$$

$$V_{18} = \frac{-2}{3.40}(+0.15+0.32+0.13+0.227) = -\frac{2}{3.40}(0.87) = 0.51$$

3 Δ's

$$+0.703\frac{\Delta_{18}}{10^4} - 10\frac{\Delta_{17}}{10^4} + 144\frac{\Delta_{16}}{10^4} = (16.40+0) = 16.40$$

$$-2.70\frac{\Delta_{18}}{10^4} + 27.20\frac{\Delta_{17}}{10^4} - 9.70\frac{\Delta_{16}}{10^4} = (12.80+0.03) = 12.83$$

$$+25.50\frac{\Delta_{18}}{10^4} - 2.82\frac{\Delta_{17}}{10^4} + 0.703\frac{\Delta_{16}}{10^4} = (9.20-0.51) = 8.69$$

$$\Delta_{16} = 0.151$$

$$\Delta_{17} = 0.565$$

$$\Delta_{18} = 0.398$$

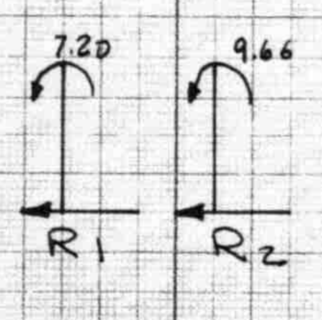
JOINT	15			16			17		17a			16a				15a			
MEMBER	I	R	S	I	R	S	I	R	L	R	I	S	L	R	I	S	L	R	I
DIST FACTOR	0.38	0.36	0.26	0.37	0.52	0.11	0.24	0.76	0.44	0.42	0.14	0.07	0.35	0.34	0.24	0.19	0.27	0.26	0.28
Influence of Δ 17						-13.50	-13.50				-13.50	-13.50							
			+2.50	+5.00	+7.00	+1.50	+0.80	+3.00	+5.90	+5.70	+1.90	+1.00	+3.50						
	-1.00	-0.90	0.60	0.30	+1.60	+1.20	+2.30	+7.40	+3.70		+0.30	+0.60	+3.20	+3.00	+2.20	+1.10	0.50		
			-0.50	-0.90	-1.30	-0.30	-0.20	-0.90	-1.80	-1.70	-0.50	-0.30	-0.70						
					+0.20	+0.20	+0.30	+0.80	+0.40		0	+0.10	+0.40	+0.30	+0.20	+0.10			
		-0.10																	
	+0.20	+0.20	+0.20	+0.10				-0.10	-0.20	0.20		-12.10	+16.45	+3.30	+2.40	-0.10	-0.25	-0.20	-0.20
				-0.20	-0.20	-0.10													
	-0.80	-0.80	+1.60					+0.10	+8.00	+3.80	-11.80					+1.10	-0.20	-0.20	-0.20
				+3.70	+7.30	-11.00	-10.30	+10.70											
Influence of Δ 16			-46.50	-46.50											-46.50	-46.50			
		+6.30	+8.60	+17.20	+24.20	+5.10	+2.60								+4.50	+8.90	+12.50	+12.10	+13.00
													+12.10						
	+12.00	+11.40	+8.20	+4.10	+5.30						+1.10	+2.10	+10.50	+10.10	+7.20	+3.60	+5.70		
		-1.30	-1.80	-3.50	-4.90	-1.00	-0.50												
													-2.50		-0.90	-1.80	-2.50	-2.40	-2.60
	+1.20	+1.10	+0.80	+0.40	+0.60	-0.30	-0.50	-1.60	-0.80		+0.10	+0.20	+1.20	+1.20	+0.80	+0.40	+0.60		
								-0.10	-0.20	-0.20	0								
		0.20	-0.10	-0.20	-0.40	-0.10	0						0.20		-0.10	-0.20	-0.30	-0.20	0.30
	+0.10	+0.10	+0.10					+0.10					+0.10	+0.10	+0.10				
	+13.30	+17.40	-30.70	-28.50	+24.80	+3.70	+1.60	-1.60	1.00	-0.20	+1.30					-35.60	+16.00	+9.50	+10.10
												+2.30	+21.20	+11.47	-34.90				
Influence of Δ 15	-93																+16.80		-33
	+35.30	+33.50	+24.20	+12.10											+7.30	+14.50	+20.60	+19.80	+21.30
		+10.30																	
			-2.30	-4.50	-6.30	-1.30	-0.70							-3.20			-1.50		
	-3.00	-2.90	-2.10	-1.10	-0.70						-0.20	-0.30	-1.40	-1.40	-1.00	-0.50			
		+0.30	+0.40	+0.70	+0.90										+0.20	+0.40	+0.50	+0.50	+0.60
						+0.20	-0.10						+0.40						
	-0.30	-0.20	-0.20	-0.10		+0.20	+0.30	+0.50	+0.30										
				-0.00	-0.10	0			-0.10	0	0	0	-0.20	-0.20	-0.20	+14.40	+36.40	+20.30	-71.10
	-61	+41	+20				-0.50	+0.00											
				+7.10	-6.20	-0.90			+0.20	0	-0.20	-0.30	-1.20	-4.80	+6.30				
Influence of Moment of Above Floor								+2.93		-4.00									
								+0.88	+1.76	+1.68	+0.56	+0.28							
						+0.25	+0.50	+1.55	+0.78										
								-0.17	-0.34	-0.33	-0.11	0.06							
			-0.05	-0.09	-0.13	-0.03	-0.02												
													-0.07						
	+0.02	+0.02	+0.01	0		+0.03	+0.05	+0.14	+0.07		0	-0.01	-0.05	-0.05	-0.04	-0.02	+0.01		
					-0.03														
	+0.02	+0.02	-0.04	0	0	0	+0.53	+2.40	-0.03	0.03	-.01								+0.01
												+0.21	-0.12	-0.05	-0.04				
				-0.09	-0.16	+0.25			+2.24	+1.32	+0.44					-0.02	+0.01	0	+0.01
Final Moments	-0.40					-5.50	-5.16	+5.16	+4.00	+1.90	-5.90	-6.05							-0.10
	+4.00					+1.10	+0.48	-0.48	-0.80	-0.06	+0.36	+0.69							+3.02
	-10.80					-0.15	-0.09	+0.09	+0.04	0	-0.04	-0.05							-12.60
	-7.20					-4.56	-4.76	+4.76	+3.74	+1.84	-5.58	-5.41							-9.66

Checking Results:

$R_1 + R_2 = \frac{7.20 + 9.66}{1.70} = \frac{16.86}{1.70} = 9.95\,T$

$\Sigma F_x = 19.90 - 2 \times 9.95 = 0$

∴ O.K.



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER :	RIAD SHAHIN	WIND ANALYSIS	
CHK'D BY :	RIAD SHAHIN	HARDY CROSS METHOD	
APP'D BY :	Dr JACK NASSER	DATE : DECEMBER 1964	SHEET Nº 59/

17-16-15 Floors

1 Shears

$V_{15} = \frac{-2}{1.70}(-0.80 - 0.20) = -\frac{2}{1.70}(-1.00) = +1.18 = +1.18\ \Delta_{17}/10^4$

$V_{16} = \frac{-2}{3.40}(+1.60 + 3.70 + 1.10 + 2.40) = \frac{-2}{3.40}(+8.80) = -5.16 = -5.16\ \Delta_{17}/10^4$

$V_{17} = \frac{-2}{3.40}(-11.00 - 10.30 - 12.10 - 11.80) = \frac{-2}{3.40}(-45.20) = +26.50 = +26.50\ \Delta_{17}/10^4$

$V_{15} = \frac{-2}{1.70}(+13.30 + 10.10) = \frac{-2}{1.70}(+23.40) = -27.50 = -27.50\ \Delta_{16}/10^4$

$V_{16} = \frac{-2}{3.40}(-30.70 - 28.50 - 35.60 - 34.90) = \frac{-2}{3.40}(-129.70) = +76 = 76\ \Delta_{16}/10^4$

$V_{17} = \frac{-2}{3.40}(+3.70 + 1.60 + 2.30 + 1.20) = \frac{-2}{3.40}(+8.80) = -5.16 = -5.16\ \Delta_{16}/10^4$

$V_{15} = \frac{-2}{1.70}(-61 - 71.10) = \frac{-2}{1.70}(-132.10) = +155 = +155\ \Delta_{15}/10^4$

$V_{16} = \frac{-2}{3.40}(+20 + 7.10 + 14.40 + 6.30) = \frac{-2}{3.40}(+47.80) = -28 = -28\ \Delta_{15}/10^4$

$V_{17} = \frac{-2}{3.40}(-0.90 - 0.50 - 0.30 - 0.20) = \frac{-2}{3.40}(-1.90) = +1.11 = +1.11\ \Delta_{15}/10^4$

2 Effect of 18th Floor

$V_{15} = \frac{-2}{1.70}(+0.02 + 0.01) = \frac{-2}{1.70}(+0.03) = -0.035$

$V_{16} = \frac{-2}{3.40}(-0.04 - 0.09 - 0.02 - 0.04) = \frac{-2}{3.40}(-0.19) = +0.111$

$V_{17} = \frac{-2}{3.40}(+0.25 + 0.53 + 0.21 + 0.44) = \frac{-2}{3.40}(+1.43) = -0.84$

3 Δ's

$+1.18\Delta_{17} - 27.50\Delta_{16} + 155\Delta_{15} = (19.90 - 0.035)10^4 = 19.86 \times 10^4$

$-5.16\Delta_{17} + 76\Delta_{16} - 28\Delta_{15} = (16.40 + 0.11)10^4 = 16.51 \times 10^4$

$+26.50\Delta_{17} - 5.16\Delta_{16} + 1.11\Delta_{15} = (12.80 - 0.84)10^4 = 11.96 \times 10^4$

$\Delta_{15} = 0.177$

$\Delta_{16} = 0.302$

$\Delta_{17} = 0.501$

JOINT	14			15			16		16a			15a				14a			
MEMBER	I	R	S	I	R	S	I	R	L	R	I	S	L	R	I	S	L	R	I
DIST. FACTOR	0.38	0.36	0.26	0.29	0.42	0.29	0.42	0.58	0.37	0.36	0.27	0.21	0.30	0.28	0.21	0.19	0.27	0.26	0.28
Influence of Δ 16					+7.00	-46.50 +10.00	-46.50 +19.50	+27	+13.50		-46.50 +4.90	-46.50 +9.80	+13.90	+13.00	+9.80	+4.90			
			+4.30	+8.60	+12.40	+8.50	+4.30	+5.20	+10.40	+10.10	+7.60	+3.80	+6.20						
	-1.60	-1.60	-1.10	-0.60	-1.50	-2.00	-4.00	-5.50	-2.80		-1.10	-2.10	-3.00	-2.80	-2.10	-1.10	-0.80		
		-0.40	+0.60	+1.20	+1.70	+1.20	+0.60	+0.70	+1.40	+1.40	+1.10	+0.60	+0.90		-0.30	-0.60	-0.80	-0.80	-0.80
	-0.10	-0.10			-0.20	-0.30	-0.50	-0.80	-0.40		-0.20	-0.30	-0.30	-0.30	-0.30	+3.20	-1.60	-0.80	-0.80
	-1.70	-2.10	+3.80	+0.10	+0.30	+0.10	-26.60	+26.60	+0.20	+0.20	+0.20	-35.30	+17.70	+9.90	7.70				
				+9.30	+19.70	-29			+22.34	+11.70	-34.00								
Influence of Δ 15	+17.70	+16.70	-46.50 +12.10	-46.50 +6.10	+7.00						+4.90	+9.80	+13.90	+13.00	-46.50 +9.80	-46.50 +4.90	+8.40		
		+4.50	+4.90	+9.70	+14.00	+9.70	+4.90						+7.00		+3.20	+6.30	+9.00	+8.60	+9.30
	-3.60	-3.40	-2.40	-1.20	-1.60	-1.10	-2.10	-2.80	-1.40		-1.10	-2.10	-3.10	-2.90	-2.10	-1.10	-1.70		
		+0.40	+0.60	+1.10	+1.70	+1.10	+0.60	-0.50	-0.90	-0.90	-0.60	-0.30	+0.90		+0.30	+0.50	+0.80	+0.70	+0.80
	-0.40	-0.40	-0.20	-0.10	-0.20		0	-0.10				-0.10	-0.30	-0.30	-0.20	-0.10	-0.20		
				+0.10	+0.10	+0.10			-2.30	-0.90	+3.20					0	-10.10	+0.10	+0.10
							+3.40	-3.40				+7.30	+18.40	+9.80	-35.50				
	+13.70	17.80	-31.50	-30.80	+21	+9.80										-36	+16.40	+9.40	+10.20
Influence of Δ 14	-93																		-93
	+35.30	+33.50	+24.20	+12.10											+7.30	+14.50	+16.80 +20.60	+19.80	+21.30
		+10.30																	
	-3.90	-3.70	-2.70	-1.40													-1.90		
			-1.60	-3.10	-4.50	-3.10	-1.60						-2.80						
											-0.50	-0.90	-1.40	-1.30	-0.90	-0.50			
					-0.70	+0.40	+0.70	+0.90	+0.50										
		+0.30							0		0				+0.30	+0.50	+0.60	+0.60	+0.70
	+0.50	+0.50	+0.30	+0.20									-0.10	-0.10	-0.10		+0.30		
	61.10	+40.90	+20.20	0	+0.10	0	-0.90	+0.90	+0.50	0	-0.50	0.90	-4.30	-1.40	+6.60		-0.10	-0.10	-0.10
				+7.80	-5.10	-2.70										+14.50	+36.30	+20.30	-71.10
Influence of Moment of Above Floor							-4.55		-5.41										
								+1.00	+2	+1.95	+1.46	+0.73							
						+0.75	+1.49	+2.06	+1.03										
			-0.11	-0.22	-0.31	-0.22	-0.11	-0.19	-0.38	-0.37	-0.28	-0.14	-0.16						
	+0.04	+0.04	+0.03	+0.02	-0.01	+0.06	+0.12	+0.18	+0.09		-0.05	-0.09	-0.13	-0.12	-0.09	-0.05	+0.02		
	+0.04	+0.04	-0.08	0	-0.01	0		0.0	-0.09	-0.01	-0.01	+0.50	-0.29	-0.12	-0.09	0	+0.01	+0.01	+0.0
				-0.20	-0.39	+0.59	0	+0.01	+2.72	+1.57	+1.12					-0.05	+0.03	+0.01	+0.0
							+1.50	+3.05											
Final Moments	-0.40					-7.48	-6.85	16.85	+5.75	+3.02	-9.77	-9.10							-0.21
	+5.20					+3.75	+1.29	-1.29	-0.87	-0.34	+1.21	+2.77							+3.87
	-13.00					-0.57	-0.19	+0.19	+0.11	0	-0.11	-0.19							-15.10
	-8.24					-4.30	-5.75	+5.75	+4.90	+2.68	-7.62	-6.52							-11.44

Checking Results:

$R_1 + R_2 = \left(\frac{8.24 + 11.44}{1.70}\right) = \frac{19.68}{1.70} = 11.60T$

$\Sigma F_x = 23.30 - 2 \times 11.60 = 0.10T$

∴ OK.

ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER: RIAD SHAHIN
CHK'D BY: RIAD SHAHIN
APP'D BY: Dr JACK NASSER

WIND ANALYSIS
HARDY CROSS METHOD

DATE: DECEMBER 1964 | SHEET No 61/

16-15-14 Floors

1 *Shears*

$V_{14} = \frac{-2}{1.70}(-1.70-0.80) = \frac{-2}{1.70}(-2.50) = +2.94 = 2.94\,\Delta_{16}/10^4$

$V_{15} = \frac{-2}{3.40}(+3.80+9.30+3.20+7.70) = \frac{-2}{3.40}(+24.00) = -14.10 = 14.10\,\Delta_{16}/10^4$

$V_{16} = \frac{-2}{3.40}(-29-26.60-35.30-34.00) = \frac{-2}{3.40}(-24.90) = +73.20 = +73.20\,\Delta_{16}/10^4$

$V_{14} = \frac{-2}{1.70}(+13.70+10.20) = \frac{-2}{1.70}(+23.90) = -28.10 = 28.10\,\Delta_{15}/10^4$

$V_{15} = \frac{-2}{3.40}(-31.50-30.80-36-35.50) = \frac{-2}{3.40}(-133.80) = +78.50 = 78.50\,\Delta_{15}/10^4$

$V_{16} = \frac{-2}{3.40}(+9.80+3.40+7.30+3.20) = \frac{-2}{3.40}(+23.70) = -13.90 = 13.90\,\Delta_{15}/10^4$

$V_{14} = \frac{-2}{1.70}(-61.10-71.10) = \frac{-2}{1.70}(-132.20) = +155 = 155\,\Delta_{14}/10^4$

$V_{15} = \frac{-2}{3.40}(+20.20+7.80+14.50+6.60) = \frac{-2}{3.40}(+49.10) = -28.80 = -28.80\,\Delta_{14}/10^4$

$V_{16} = \frac{-2}{3.40}(-2.70-0.90-0.90-0.50) = \frac{-2}{3.40}(-5.00) = +2.93 = +2.93\,\Delta_{14}/10^4$

2 *Effect of 17th floor.*

$V_{14} = -\frac{2}{1.70}(+0.04+0.01) = -\frac{2}{1.70}(+0.05) = -0.06$

$V_{15} = \frac{-2}{3.40}(-0.08-0.20-0.05-0.09) = \frac{-2}{3.40}(-0.42) = +0.25$

$V_{16} = \frac{-2}{3.40}(+0.59+1.50+0.50+1.12) = \frac{-2}{3.40}(+3.71) = -2.18$

3 Δ'S

$+2.94\,\Delta_{16} - 28.10\,\Delta_{15} + 155\,\Delta_{14} = (23.30-0.06)10^4 = 23.24\times10^4$

$-14.10\,\Delta_{16} + 78.00\,\Delta_{15} - 28.80\,\Delta_{14} = (19.90+0.25)10^4 = 20.15\times10^4$

$+73.20\,\Delta_{16} - 13.90\,\Delta_{15} + 2.93\,\Delta_{14} = (16.40-2.18)10^4 = 14.20\times10^4$

$\Delta_{14} = 0.212$

$\Delta_{15} = 0.380$

$\Delta_{16} = 0.258$

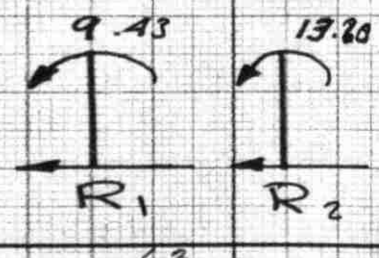
JOINT	13			14			15		15a			14a				13a			
MEMBER	I	R	S	I	R	S	I	R	L	R	I	S	L	R	I	S	L	R	I
DIST. FACTOR	0.38	0.36	0.26	0.29	0.42	0.29	0.42	0.58	0.37	0.36	0.27	0.21	0.30	0.28	0.21	0.19	0.27	0.26	0.28
Moment of Above Floor								-4.30		-6.52									
								+1.20	+2.41	+2.35	+1.76	+0.88							
					-0.13	+0.65	+1.30	+1.80	+0.90		-0.09	-0.18	-0.26	-0.26	-0.18	-0.09			
			-0.08	-0.15	-0.22	-0.15	-0.08	-0.15	-0.30	-0.29	-0.22	-0.11	-0.11						
					+0.03	+0.05	+0.09	+0.14	+0.07		+0.03	+0.05	+0.06	+0.06	+0.05	+0.03			
		+0.01	-0.01	-0.02	-0.04	-0.02	-0.01	-0.02	-0.04	-0.04	-0.02	-0.01	-0.02			0	+0.02	+0.02	+0.02
	+0.03	+0.03	+0.02	+0.01			+0.01	+0.02	+3.04	+2.02	+1.46		+0.01	+0.01	+0.01	0	+0.02		
				0	0.01	0										0	-0.01	0	-0.01
	+0.03	+0.04	-0.07									+0.63	-0.32	-0.19	-0.12				
				-0.16	-0.37	+0.53	+1.31	+2.99								-0.06	+0.03	+0.02	+0.01
Final Moments	-0.53					-9.05	-8.32	+8.32	+7.00	+3.66	-10.66	-4.05							-0.25
	+6.10					+4.35	+1.51	-1.51	-1.02	-0.40	+1.42	+3.25							+4.55
	-15.00					-0.66	-0.22	+0.22	+0.12	0	-0.12	-0.22							-17.50
	-9.43					-5.36	-7.03	+7.03	+6.10	+3.26	-9.36	-8.02							13.20

Checking Results:

$$R_1 + R_2 = \frac{9.43 + 17.65}{1.70} = \frac{22.63}{1.70} = 13.35\,T$$

$$\Sigma F_x = 26.70 - 2 \times 13.35 = 0\,T$$

$\therefore$ O.K.



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER : RIAD SHAHIN	WIND ANALYSIS	
CHK'D BY : RIAD SHAHIN	HARDY CROSS METHOD	
APP'D BY : Dr. JACK NASSER	DATE: DECEMBER 1964	SHEET No 63 /

15-14-13 Floors

1 Shears (same as previous case)

2 Effect of 16^{th} floor

$$V_{13} = \frac{-2}{1.70}(+0.03+0.01) = \frac{-2}{1.70}(+0.04) = -0.05$$

$$V_{14} = \frac{-2}{3.40}(-0.07-0.16-0.06-0.12) = \frac{-2}{3.40}(-0.41) = +0.24$$

$$V_{15} = \frac{-2}{3.40}(+0.53+1.31+0.63+1.46) = \frac{-2}{3.40}(+3.93) = -2.30$$

3 Δ's

$$+2.94\Delta_{15} - 28.10\Delta_{14} + 15.5\Delta_{13} = (26.70-0.05)10^4 = 26.65\times10^4$$

$$-14.10\Delta_{15} + 78.50\Delta_{14} - 28.80\Delta_{13} = (23.30+0.24)10^4 = 23.54\times10^4$$

$$+73.20\Delta_{15} - 13.90\Delta_{14} + 2.93\Delta_{13} = (19.90-2.30)10^4 = 17.60\times10^4$$

$\Delta_{13} = 0.245$

$\Delta_{14} = 0.446$

$\Delta_{15} = 0.314$

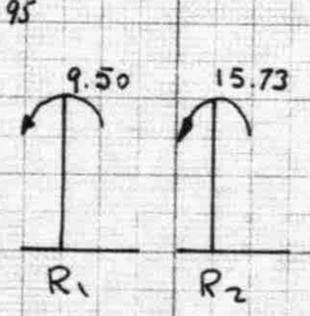
JOINT	12			13			14		14a			13a				12a			
MEMBER	I	R	S	I	R	S	I	R	L	R	I	S	L	R	I	S	L	R	I
DIST FACTOR	0.53	0.32	0.15	0.29	0.42	0.29	0.42	0.58	0.37	0.36	0.27	0.21	0.30	0.28	0.21	0.12	0.24	0.24	0.40
Influence of Δ 14						-46.50	-46.50				-46.50	-46.50							
					+7.00	+10.00	+19.50	+2.20	+13.50		+4.90	+9.80	+13.90	+13.00	+9.80	+4.90			
			+4.30	+8.60	+12.40	+8.50	+4.30	+5.20	+10.90	+10.10	+7.60	+3.80	+6.20						
	-2.30	-1.40	-0.60	-0.30	-1.50	-2.00	-4.00	-5.50	-2.80		-1.10	-2.10	-3.00	-2.80	-2.10	-1.10	-0.70		
		-0.40	+0.60	+1.10	+1.60	+1.10	+0.60	+0.70	+1.40	+1.40	+1.10	+0.60	+0.80		-0.20	-0.40	-0.70	-0.80	-1.20
	-0.10	-0.10		0	-0.20	-0.30	-0.50	-0.80	-0.40		-0.20	-0.30	-0.30	-0.30	-0.30	-0.20			
	-2.40	-1.90	+4.30	+0.20	+0.20	+0.10	0	+0.10	+0.20	+0.20	+0.20	+0.10	+0.10			0	+0.10	+0.10	0
				+9.60	+19.50	-29.10	0	-0.10	+22.30	+11.70	-34	0	-0.10	-0.10	0	+3.20	-1.30	-0.70	-1.20
							-26.60	+26.60				-34.00	+17.60	+9.80	+7.20				
Influence of Δ 13			-46.50	-46.50											-46.50	-46.90			
	+24.50	+15.00	+7.00	+3.50	+7.00						+4.90	+9.80	+13.90	+13.00	+9.80	+4.90	+7.50		
		+4.10	+5.10	+10.30	+15.40	+10.30	+5.10								+2.10	+4.10	+8.20	+8.20	+13.60
						-1.10	-2.20	-2.90	-1.50				+7.70						
	-4.90	-2.90	-1.40	-0.70	-1.40						-1.00	-2.00	-3.00	-2.80	-2.00	-1.00	-1.50		
		+0.30	+0.50	+1.00	+1.20	+1.00	+0.50	-0.50	-0.90	-0.90	-0.60	-0.30	+0.60		+0.20	+0.30	+0.60	+0.60	+1.00
	-0.40	-0.20	-0.20	-0.10			0	0	-2.40	-0.90	+3.30	-0.10	-0.20	-0.10	-0.10				
					+0.10												-0.10		
	+19.20	+16.30	-35.50				+3.40	-3.40											+0.10
				-32.50	+22.30	+10.20						+7.40	+19.00	+10.10	-36.50				
																-38.20	+14.72	+8.80	+14.75
Influence of Δ 12	-2.20																		
																			-220
	+1.16	+70	+34	+17															
																	+35		
		+22.20													+11.10	+22.20	+44.40	+44.40	+74
	-11.80	-7.10	-3.30	-1.80															
																	-3.60		
			-2.20	-4.40	-6.40	-4.40	-2.20						-3.20						
						+0.50	+0.90	+1.30	+0.70		-0.90	-1.70	-2.40	-2.10	-1.70	-0.90			
					-1.20														
		+0.60																	
	+0.90	+0.50	+0.20	+0.10				0	+0.10	+0.10	0				+0.30	+0.50	+1.10	+1.10	+1.80
				+0.20	+0.20	+0.20	+0.10										+0.30		
	-114.90	+86.20	+28.70						+0.80	+0.10	-0.90		+0.10						
								-0.10											
				+11.10	-7.40	-3.70						-0.10	-0.10	-0.10	-0.10	0	-0.10	-0.10	-0.10
							-1.20	+1.20											
												-1.80	-5.60	-2.20	+9.60	+2.80	+77.10	+45.40	-144.30
Influence of Moment of Above Floor							-5.36		-8.02										
								+1.50	+3	+2.90	+2.12	+1.06							
						+0.81	+1.62	+2.24	+1.12										
								-0.21	-0.42	-0.40	-0.30	-0.15							
					-0.14														
											-0.10	-0.19	-0.27	-0.26	-0.19	-0.10			
			-0.10	-0.20	-0.28	-0.19	-0.10												
													-0.14						
	+0.05	+0.03	+0.02	+0.01		+0.07	+0.13	+0.18	+0.09		+0.02	+0.03	+0.04	+0.04	+0.03	+0.02	-10.02		
					+0.02														
	+0.05	+0.03	-0.08	-0.03	-0.04	-0.03	+1.65	+3.71	-0.01	0	0					0	+0.02	+0.02	+0.02
												+0.75	-0.37	-0.22	-0.16				
				-0.22	-0.44	+0.66			+3.78	+2.50	+1.74					-0.08	+0.04	+0.02	+0.02
Final Moments	-0.86					-10.45	-9.55	+9.55	+8.00	+4.20	-12.2	-12.40							-0.43
	+8.76					+4.70	+1.55	-1.55	-1.00	-0.41	+1.50	+3.40							+6.70
	-17.40					-0.56	-0.18	+0.18	+0.12	+0.02	-0.14	-0.27							-22.00
	-9.50					-6.31	-8.18	+8.18	+7.03	+3.81	-10.84	-9.22							-15.73

Checking Results:

$R_1 + R_2 = \frac{9.50 + 15.73}{1.70} = \frac{25.23}{1.70} = 14.95$

$\Sigma F_x = 30 - 14.95 \times 2 = 0.10T$

∴ O.K.



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER : RIAD SHAHIN	WIND ANALYSIS	
CHK'D BY : RIAD SHAHIN	HARDY CROSS METHOD	
APP'D BY : Dr JACK NASSER	DATE : DECEMBER 1964	SHEET No 65/

14-13-12 Floors

1. *Shears*

$V_{12} = \frac{-2}{1.70}(-2.40-1.20) = \frac{-2}{1.70}(-3.60) = +4.42 = +4.42\,\Delta_{14}/10^4$

$V_{13} = \frac{-2}{3.40}(+4.30+9.60+3.20+7.20) = \frac{-2}{3.40}(+24.30) = 14.20 = 14.20\,\Delta_{14}/10^4$

$V_{14} = \frac{-2}{3.40}(-29.10-26.60-34.60-34.00) = \frac{-2}{3.40}(124.30) = +73 = +73\,\Delta_{14}/10^4$

$V_{12} = \frac{-2}{1.70}(+19.20+14.70) = \frac{-2}{1.70}(+33.90) = -40 = -40\,\Delta_{13}/10^4$

$V_{13} = \frac{-2}{3.40}(-35.50-32.50-38.20-36.50) = \frac{-2}{3.40}(-142.70) = +84 = +84\,\Delta_{13}/10^4$

$V_{14} = \frac{-2}{3.40}(+10.20+3.40+7.40+3.30) = \frac{-2}{3.40}(+24.30) = -14.10 = -14.10\,\Delta_{13}/10^4$

$V_{12} = \frac{-2}{1.70}(-114.90-144.30) = \frac{-2}{1.70}(-259.20) = +305 = +305\,\Delta_{12}/10^4$

$V_{13} = \frac{-2}{3.40}(+28.70+11.10+21.80+9.18) = \frac{-2}{3.40}(+71.20) = -41.80 = 41.80\,\Delta_{12}/10^4$

$V_{14} = \frac{-2}{3.40}(-3.70-1.20-1.80-0.90) = \frac{-2}{3.40}(-7.60) = +4.45 = +4.45\,\Delta_{12}/10^4$

2. *Effect of 15th floor.*

$V_{12} = \frac{-2}{1.70}(+0.05+0.02) = \frac{-2}{1.70}(+0.07) = -0.08$

$V_{13} = \frac{-2}{3.40}(-0.08-0.22-0.08-0.16) = \frac{-2}{3.40}(-0.54) = +0.32$

$V_{14} = \frac{-2}{3.40}(+0.66+1.65+0.75+1.74) = \frac{-2}{3.40}(+4.80) = -2.82$

3. *Δ'S*

$+4.42\,\Delta_{14} - 40\,\Delta_{13} + 305\,\Delta_{12} = (30.00-0.08)\,10^4 = 29.92 \times 10^4$

$-14.20\,\Delta_{14} + 84\,\Delta_{13} - 41.80\,\Delta_{12} = (26.70+0.32)\,10^4 = 27.02 \times 10^4$

$+73\,\Delta_{14} - 14.10\,\Delta_{13} + 4.45\,\Delta_{12} = (23.30-2.82)\,10^4 = 20.48 \times 10^4$

$\Delta_{12} = 0.152$

$\Delta_{13} = 0.457$

$\Delta_{12} = 0.359$

JOINT	11			12			13		13a			12a				11a			
MEMBRE	I	R	S	I	R	S	I	R	L	R	I	S	L	R	I	S	L	R	I
DIST FACTOR	0.44	0.27	0.29	0.43	0.39	0.18	0.42	0.58	0.37	0.36	0.27	0.13	0.28	0.27	0.32	0.24	0.24	0.20	0.35
Influence of △13						-46.50	-46.50				-46.50	-46.50							
					+6.50	+10.00	+19.50	+27.00	+13.50		+3.00	+6.00	+13.00	+12.50	+15.00	+7.50			
			+6.50	+12.90	+11.70	+5.40	12.70	+5.60	+11.10	+10.80	+8.10	+4.10	+5.90						
											-0.70	-1.30	-2.80	-2.70	-3.20	-1.60			
	-2.80	-1.80	-1.90	-1.00	-1.40	-1.80	-3.50	-4.80	-2.40								-0.90		
									+1.20	+1.10	+0.80	+0.40			-0.60	-1.20	-1.00	-1.00	-1.80
		-0.50	+0.90	+1.80	+1.70	+0.70	+0.40	+0.60					+0.90						
	-0.20	-0.10	-0.20	0		-0.20	-0.40	-0.60	-0.30		-0.10	-0.10	-0.20	-0.20	-0.20	+4.70	-1.90	-1.00	-1.80
					-0.10														
				+0.10	+0.10	+0.10			+0.20	+0.20	+0.00								
	-3.00	-2.40	+5.40				-27.80	+27.80				-37.40	+16.80	+9.60	+11				
				+13.80	+18.50	-32.30			+23.30	+12.10	-35.40								
Influence of △12			-110	-110											-110	-110			
	+48	+30	+32	+16													+15		
					+15.50						+7.00	+14	+31	+30	+35	+17.50			
			+16.90	+33.80	+30.60	+14.10	+7.10												
		+8.20											+15.30		+9.30	+18.60	+16.30	+15.50	+27.10
	-11.00	-6.80	-7.30	-3.70															
					-3.40						-1.60	-3.20	-6.80	-6.60	-8.00	-4.00	-3.40		
			+1.50	+3.00	+2.80	+1.30	+0.60								+0.90	+1.80	+1.60	+1.50	+2.50
													+1.40						
		+0.80				-1.60	-3.20	-4.50	-2.80										
			+0.40	+0.70	+0.60	+0.30	+0.20	-0.50	-1.00	-0.90	-0.70	-0.40							
													+0.30						
	-1.20	-0.70	-0.80	-0.40			+0.0	+0.20			-0.20	-0.30	-0.60	-0.60	-0.70	-0.30			
					-0.30												-0.40		
				+0.30	+0.30	0.10	+4.80	-4.80	+0.10	+0.10	0		+0.30		+0.10	+0.20	+0.20	+0.20	+0.20
	+35.80	+31.50	-67.30																
				-60.30	+46.10	+14.20			-3.70	-0.80	+4.50	-0.10	-0.10	-0.10	-0.10	-76.20	+29.30	+17.10	+29.80
												+10.00	+40.80	+22.70	-73.50				
Influence of △11	-2.20																		-2.20
	19 +	+59	+64	+32													+28.50		
															+22.90	+45.70	+40.00	+38.20	+66.60
		+20.00	-6.90	-13.70	-12.50	-5.80	-2.90						-6.30						
											-1.10	-2.20	-4.60	-4.50	-5.30	-2.70			
	-5.80	-3.50	-3.80	-1.90	-2.30	+0.60	+1.20	+1.70	+0.90								-1.80		
															+0.60	+1.10	+0.90	+0.90	+1.60
		+0.50	+0.80	+1.60	+1.40	+0.60	+0.30						+0.70						
							-0.10	-0.20			-0.10	-0.20	-0.40	-0.30	-0.40	-0.20			
	-0.60	-0.30	-0.40	-0.20	-0.20				+0.10	+0.10	+0.10						-0.20		
				+0.20	+0.20	0													
	-129.40	+75.70	+53.70				-1.50	+1.50	+1.00	+0.10	-1.10	-2.40	-10.60	-4.80	+17.80	+0.10	+0.10	+0.10	+0.10
				+19.00	-13.40	-4.60										+44	+68.50	+39.20	-151.70
Influence of Moment of Above Floor							-6.31		-9.27										
								+1.72	+3.44	+3.33	+2.50	+1.25							
						+0.97	+1.93	+2.66	+1.33										
								-0.25	-0.49	-0.48	-0.36	-0.18							
					-0.15						-0.07	-0.14	-0.30	-0.29	-0.34	-0.17			
			-0.18	-0.35	-0.32	-0.15	-0.08										+0.03		
	+0.08	+0.05	+0.05	+0.03		+0.07	+0.14	+0.19	+0.10				-0.16						
											+0.01	+0.02	+0.04	+0.04	+0.06	+0.03			
					+0.02			-0.01	-0.02	-0.02	0.0								
		+0.02	-0.03	-0.05	-0.05	-0.02	-0.01					+0.95	-0.42	+0.25	-0.28	-0.03	+0.02	+0.02	+0.04
	+0.01	0	0				+0.01	+0.01	+4.36	+2.83	+2.08								
				-0.37	-0.50	+0.87										-0.11	+0.05	+0.02	+0.04
	+0.09	+0.07	-0.16				+1.99	+4.32											
Final Moments	-1.10					-11.70	-10.10	+10.10	+8.45	+4.40	-12.85	-13.50							-0.65
	+11.10					+4.40	+1.50	-1.50	-1.15	-0.25	+1.40	+3.10							+9.25
	-21.50					-0.90	-0.25	+0.25	+0.20	+0.02	-0.22	-0.40							-25.20
	-11.50					-8.10	-8.85	+8.85	+7.50	+4.17	-11.67	-10.80							-16.60

Checking Results:

$R_1 + R_2 = \frac{11.50 + 16.60}{1.70} = \frac{28.10}{1.70} = 16.55\,T$

11.50 16.60

$\Sigma F_x = 33.20 - 2 \times 16.55 = 0.10\,T$

∴ O.K.

R_1 R_2

ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER :	RIAD SHAHIN	WIND ANALYSIS
CHK'D BY :	RIAD SHAHIN	HARDY CROSS METHOD
APP'D BY :	Dr. JACK NASSER	DATE: DECEMBER 1964 SHEET Nº 67 /

13 - 12 - 11 Floors

1. *Shears*

$V_{11} = \frac{-2}{1.70}(-300-1.80) = \frac{-2}{1.70}(-4.80) = +5.65 = 5.65\,\Delta_{13}/10^4$

$V_{12} = \frac{-2}{3.40}(+5.40+13.80+4.70+11.00) = \frac{-2}{3.40}(+34.90) = -20.50 = -20.50\,\Delta_{13}/10^4$

$V_{13} = \frac{-2}{3.40}(-32.30-27.80-37.40-35.40) = \frac{-2}{3.40}(-132.90) = +78 = +78\,\Delta_{13}/10^4$

$V_{11} = \frac{-2}{1.70}(+35.80-29.80) = \frac{-2}{1.70}(+65.60) = -78.20 = -78.20\,\Delta_{12}/10^4$

$V_{12} = \frac{-2}{3.40}(-67.30-60.30-76.20-73.50) = \frac{-2}{3.40}(-277.30) = +163 = +163\,\Delta_{12}/10^4$

$V_{13} = \frac{-2}{3.40}(+14.20+4.80+10.00+4.50) = \frac{-2}{3.40}(+33.50) = -19.70 = 19.70\,\Delta_{12}/10^4$

$V_{11} = \frac{-2}{1.70}(-129.40-151.70) = \frac{-2}{1.70}(-281.10) = +330 = +330\,\Delta_{11}/10^4$

$V_{12} = \frac{-2}{3.40}(+53.70+18.00+44+17.80) = \frac{-2}{3.40}(+133.50) = 78.20 = -78.20\,\Delta_{11}/10^4$

2. *Effect of 14 th floor*

$V_{11} = \frac{-2}{1.70}(+0.09+0.04) = \frac{-2}{1.70}(+0.13) = -0.15$

$V_{12} = \frac{-2}{3.40}(-0.16-0.37-0.11-0.28) = \frac{-2}{3.40}(-0.92) = +0.54$

$V_{13} = \frac{-2}{3.40}(+0.87+1.99+0.95+2.08) = \frac{-2}{3.40}(+5.89) = -3.46$

3. *Δ's*

$+5.65\,\Delta_{13} - 78.20\,\Delta_{12} + 330\,\Delta_{11} = (33.20-0.15)10^4 = 33.05\times10^4$

$-20.50\,\Delta_{13} + 163\,\Delta_{12} - 78.20\,\Delta_{11} = (30.00+0.54)10^4 = 30.54\times10^4$

$+78\,\Delta_{13} - 19.70\,\Delta_{12} + 5.64\,\Delta_{11} = (26.70-3.46)10^4 = 23.24\times10^4$

$\Delta_{11} = 0.166$

$\Delta_{12} = 0.312$

$\Delta_{13} = 0.363$

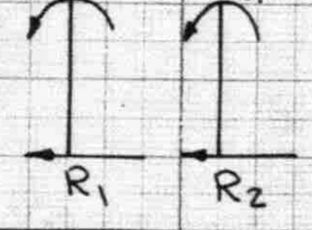
JOINT	10			11			12		12a			11a				10a			
MEMBER	I	R	S	I	R	S	I	R	L	R	I	S	L	R	I	S	L	R	I
DIST. FACTOR	0.44	0.27	0.29	0.34	0.32	0.34	0.53	0.47	0.32	0.32	0.36	0.27	0.24	0.23	0.26	0.24	0.21	0.20	0.35
Influence of Δ 12						-110	-110				-110	-110							
					+13	+29	+58	+52	+26		+15	+30	+26	+25	+29	+15.50			
			+11.50	+23	+22	+23	+11.50	+11	+22	+22	+25	+14.50	+11						
		-1.30			-3.10	-7.00	-11.90	-10.60	-5.30		-3.50	-6.90	-6.10	-5.90	-6.60	-3.30			
								+1.40	+2.80	+2.80	+3.20	+1.60			-1.50	-2.90	-2.60	-2.40	-4.30
	-4.50	-2.70	-3.00	-1.50													-1.40		
			+2.00	+3.90	+3.70	+4.00	+2.00						+1.90						
	-0.90	-0.50	-0.60	-0.30	-0.30	-0.90	-1.80	-1.60	-0.80		-0.30	-0.50	-0.50	-0.50	-0.50	-0.30	-0.30		
		+0.20	+0.30	+0.50	+0.50	+0.50	+0.30	+0.20	+0.40	+0.30	+0.40	+0.20	+0.30		+0.30	+0.50	+0.40	+0.40	+0.70
	-0.20	-0.10	-0.20				-0.30	-0.20				-0.20	-0.20	-0.20	-0.20				
	5.60	-4.40	+10	+25.60	+35.80	-61.40	-52.20	+52.20	+45.10	+25.10	-70.20	-71.30	+32.40	+18.40	+20.50	+9.50	-3.90	-2.00	-3.60
Influence of Δ 11			-110	-110											-110	-110			
	+48	+30	+32	+16	+13						+15	+30	+26	+25	+29	+14.50	+15		
		+8.50	+13.50	+27.50	+26	+27.50	+13.80						+13		+9.70	+19.30	+17.00	+16.00	+28.20
	-9.70	-5.90	-6.40	-3.20	-2.80	-3.70	-7.30	-6.50	-3.30		-3.10	-6.10	-5.50	-5.20	-5.90	-3.00	-3.00		
		+0.70	+1.70	+3.30	+3.10	+3.30	+1.70	-1.40	-2.80	-2.80	-3.00	-1.50	+1.60		+0.70	+1.40	+1.30	+1.20	+2.10
	-1.10	-0.60	-0.70	-0.40	-0.10	-0.10	-0.20	-0.10	0		-0.10	-0.20	-0.20	-0.20	-0.20	-0.10	-0.30		
				+0.20	-0.14	+0.20			0	0	+0.10					+0.10	+0.10	+0.10	+0.10
	+37.20	+32.70	-69.90	-66.60	+39.30	+27.30	+8	-8	-6.10	-2.80	+8.90	+22.20	-34.90	+19.60	-76.70	-77.80	+30.10	+17.30	+30.40
Influence of Δ 10	-220																		-220
	+97	+59	+64	+32													+29.50		
		+20	-5.50	-11	-10	-11	-5.50								+23.00	+46.00	+40.00	+38.00	+66.50
					-2						-2.50	-5	-5 -4	-4	-5	-2.50	-2		
	-6.40	-3.90	-4.20	-2.10		+1.50	+2.90	+2.60	+1.30						+0.60	+1.10	+0.90	+0.90	+1.60
		+0.50	+0.50	+0.90	+0.80	+0.90	+0.50	+0.20	+0.40	+0.40	+0.40	+0.20	+0.40			+44.60	+68.40	+38.90	-151.91
	-0.40	-0.30	-0.30				-0.40	-0.30				-0.30	-0.30	-0.30	-0.30				
	-129.80	+75.40	+54.40	+19.80	-11.20	-8.60	-2.50	+2.50	+1.70	+0.40	-2.10	-5.10	-8.90	-4.30	+18.30				
Influence of Moment of Above Floor							-8.10			-10.80									
								+1.73	+3.45	+3.45	+3.90	+1.95							
					-0.24	+1.69	+3.37	+3.00	+1.50		-0.27	-0.53	-0.47	-0.45	-0.50	-0.25			
			-0.25	-0.49	-0.47	-0.49	-0.25						-0.24						
	+0.10	+0.07	+0.08	+0.04				-0.20	-0.39	-0.39	-0.45	-0.23							
					+0.06	+0.12	+0.24	+0.21	+0.11		+0.06	+0.13	+0.11	+0.11	+0.12	+0.06	+0.04		
			-0.04	-0.07	-0.07	-0.08	-0.04	-0.03	-0.05	-0.06	-0.06	-0.03	-0.04		+0.02	+0.04	+0.03	+0.03	+0.05
	+0.01	+0.02 0	+0.01			+0.02	+0.04	+0.03	+0.02		+0.01	+0.02	+0.01	+0.01	+0.01	-0.15	+0.07	+0.03	+0.05
				-0.01	0	-0.01			-0.01	-0.01	-0.01								
	+0.11	+0.09	-0.20	-0.53	-0.72	+1.25	+3.36	+4.74	+4.63	+2.99	+3.18	+1.31	-0.63	-0.33	-0.35				
Final Moments	-1.28					-14.00	-11.90	+11.90	+10.30	+5.76	-16	-16.30							-0.82
	+12.30					+9.10	+2.70	-2.70	-2.00	-0.93	+2.95	+7.40							+10.00
	-23.70					-1.56	-0.45	+0.45	+0.31	+0.07	-0.38	-0.93							-27.60
	-12.68					-6.46	-9.65	+9.65	+8.59	+4.84	-13.43	-9.83							-18.42

Checking Results:

$R_1 + R_2 = \frac{12.68 + 18.42}{1.70} = \frac{31.10}{1.70} = 18.30T.$

$\Sigma F_x = 36.40 - 2 \times 18.20 = 0T.$

$\therefore$ OK.



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER :	RIAD SHAHIN	WIND ANALYSIS
CHK'D BY :	RIAD SHAHIN	HARDY CROSS METHOD
APP'D BY :	Dr. JACK NASSER	DATE : DECEMBER 1984 — SHEET No 69

12 - 11 - 10 Floors

1. Shears

$$V_{10} = \frac{-2}{1.70}(-5.60-3.60) = \frac{-2}{1.70}(-9.20) = +10.80 = +10.80\,\Delta_{12}/10^4$$

$$V_{11} = \frac{-2}{3.40}(+10+25.60+9.50+20.50) = \frac{-2}{3.40}(+65.60) = -38.50 = 38.50\,\Delta_{12}/10^4$$

$$V_{12} = \frac{-2}{3.40}(-61.40-52.20-71.30-70.20) = \frac{-2}{3.40}(-255.10) = +150 = +150\,\Delta_{12}/10^4$$

$$V_{10} = \frac{-2}{1.70}(+37.20+30.40) = \frac{-2}{1.70}(+67.60) = -79.50 = -79.50\,\Delta_{11}/10^4$$

$$V_{11} = \frac{-2}{3.40}(-69.90-66.60-77.80-76.70) = \frac{-2}{3.40}(-291.30) = +171 = +171\,\Delta_{11}/10^4$$

$$V_{12} = \frac{-2}{3.40}(+27.30+8+22.20+8.90) = \frac{-2}{3.40}(+58.40) = -34.30 = -34.30\,\Delta_{11}/10^4$$

$$V_{10} = \frac{-2}{1.70}(-129.80-151.90) = \frac{-2}{1.70}(-281.70) = +331 = +331\,\Delta_{10}/10^4$$

$$V_{11} = \frac{-2}{3.40}(+54.40+19.80+44.60+18.40) = \frac{-2}{3.40}(+137.20) = -80.80 = -80.80\,\Delta_{10}/10^4$$

$$V_{12} = \frac{-2}{3.40}(-8.60-2.50-5-2.10) = \frac{-2}{3.40}(-18.20) = +10.70 = +10.70\,\Delta_{10}/10^4$$

2. Effect of 13th floor.

$$V_{10} = \frac{-2}{1.70}(+0.11+0.05) = \frac{-2}{1.70}(+0.16) = -0.19$$

$$V_{11} = \frac{-2}{3.40}(-0.20-0.53-0.15) = \frac{-2}{3.40}(-1.23) = +0.72$$

$$V_{12} = \frac{-2}{3.40}(+1.25+3.36+1.31+3.18) = \frac{-2}{3.40}(+9.10) = -5.32$$

3. Δ's

$$+10.80\,\Delta_{12} - 79.50\,\Delta_{11} + 331\,\Delta_{10} = (36.40-0.19)10^4 = 36.21 \times 10^4$$

$$-38.50\,\Delta_{12} + 171\,\Delta_{11} - 80.20\,\Delta_{10} = (23.20+0.72)10^4 = 33.92 \times 10^4$$

$$+151\,\Delta_{12} - 34.30\,\Delta_{11} + 10.70\,\Delta_{10} = (30.00-5.30)10^4 = 24.68 \times 10^4$$

$$\Delta_{10} = 0.182$$

$$\Delta_{11} = 0.334$$

$$\Delta_{12} = 0.228$$

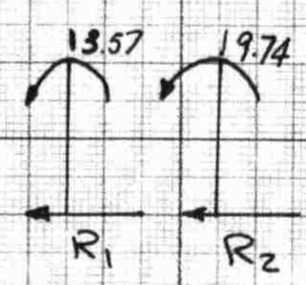
JOINT	9			10			11		11a			10a				9a			
MEMBER	I	R	S	I	R	S	1	R	L	R	1	S	L	R	I	S	L	R	1
DIST. FACTOR	0.44	0.27	0.29	0.34	0.32	0.34	0.53	0.47	0.32	0.32	0.36	0.27	0.24	0.23	0.26	0.24	0.21	0.20	0.35
Moment of Above Floor							-6.46		-9.83										
								+1.58	+3.15	+3.15	+3.53	+1.77							
					-0.21	+1.29	+2.58	+2.30	+1.15		-0.24	-0.48	-0.42	-0.41	-0.46	-0.23			
			-0.19	-0.37	-0.34	-0.37	-0.19	-0.15	-0.29	-0.29	-0.33	-0.17	-0.17						
	+0.08	+0.05	+0.06	+0.03	+0.04	+0.09	+0.18	+0.16	+0.08		+0.05	+0.09	+0.08	+0.08	+0.09	+0.05	+0.03		
									-0.04	-0.04	-0.05	-0.03							
		+0.02	-0.03	-0.06	-0.05	-0.05	-0.03	-0.02					-0.03		+0.02	+0.04	+0.03	+0.03	+0.05
	+0.01	0	0				+0.03	+0.02	+4.05	+2.82	+2.96	+0.01	+0.01	+0.01	+0.01				
				-0.40	-0.56	+0.96	+2.57	+3.89				+1.19	-0.53	-0.32	-0.34	-0.14	+0.06	+0.03	+0.05
	+0.09	+0.07	-0.16																
Final Moments	-1.47					-16.10	-13.70	+13.70	+11.80	+6.55	-18.35	-18.70							-0.94
	+13.60					+10.50	+2.95	-2.95	-2.25	-1.03	+3.28	+8.20							+11.20
	-25.76					-1.70	-0.50	+0.50	+0.34	+0.08	-0.42	-1.00							-30.10
	-13.57					-7.80	-11.25	+11.25	+9.89	+5.60	-15.49	-11.50							-19.74

Checking Results:

$R_1 + R_2 = \frac{13.57 + 19.74}{1.70} = 19.75\,T.$

$\Sigma F_x = 39.55 - 2 \times 19.75 = 0.05$

∴ O.K.



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER: RIAD SHAHIN	WIND ANALYSIS	
CHK'D BY: RIAD SHAHIN	HARDY CROSS METHOD	
APP'D BY: Dr. JACK NASSER	DATE: DECEMBER 1964	SHEET No. 71

11 - 10 - 9 Floors

1. Shears (same as previous case)

2. Effect of 13th floor

$$V_9 = \frac{-2}{1.70}(+0.09+0.05) = \frac{-2}{1.70}(+0.14) = 0.17$$

$$V_{10} = \frac{-2}{3.40}(-0.16-0.40-0.14-0.34) = \frac{-2}{3.40}(-1.04) = +0.60$$

$$V_{11} = \frac{-2}{3.40}(+0.96+2.57+1.19+2.96) = \frac{-2}{3.40}(+7.68) = -4.48$$

3 Δ'S

$$+10.80\Delta_{11} - 79.50\Delta_{10} + 331\Delta_9 = (39.55-0.17)10^4 = 39.38\times10^4$$

$$-38.50\Delta_{11} + 171\Delta_{10} - 80.80\Delta_9 = (36.40+0.60)10^4 = 37.00\times10^4$$

$$+150\Delta_{11} - 34.30\Delta_{10} + 10.70\Delta_9 = (33.20-4.48)10^4 = 28.78\times10^4$$

$$\Delta_9 = 0.198$$

$$\Delta_{10} = 0.369$$

$$\Delta_{11} = 0.262$$

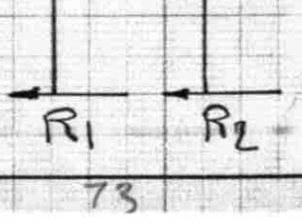
JOINT	8			9			10		10a			9a				8a			
MEMBER	I	R	S	I	R	S	I	R	L	R	I	S	L	R	I	S	L	R	I
DIST FACTOR	0.56	0.25	0.19	0.34	0.32	0.34	0.53	0.47	0.32	0.32	0.36	0.27	0.24	0.23	0.26	0.16	0.20	0.19	0.45
Influence of Δ 10						-110	-110				-110	-110							
					+13	+29	+58	+52	+26		+15	+30	+26	+25	+29	+15.50			
			+11.50	+23	+22	+28	+11.50	+11	+22	+22	+25	+14.50	+11						
						-6	-12	-10.50	-5.30		-3.40	-6.80	-6.20	-5.90	-6.60	-3.30			
					-3.10														
		-1.20						-1.40	+2.80	+2.80	+3.10	+1.60			-1.00	-2.00	-2.40	-2.30	-5.50
	-5.80	-2.50	-2.00	-1.00													-1.30		
			+1.70	+3.40	+3.30	+3.40	+1.70						+1.70						
	-1.00	-0.40	-0.30	-0.20	-0.30						-0.30	-0.60	-0.60	-0.50	-0.50	-0.30	-0.20		
		+0.20	+0.10	+0.20	+0.10	+0.20	+0.10								+0.20	+0.30	+0.40	+0.40	+0.70
	-0.10	-0.10	-0.10				-0.20	-0.20	-0.10										
				+25.40	+35	-60.40			+0.10	+0.10	+0.20	+0.10				+10.20	-3.50	-1.90	-4.80
	-6.90	-4.00	+10.90									-0.10	-0.10	0	-0.10				
							-50.90	+50.90											
									+45.50	+24.90	-70.40								
												-81.30	+31.70	+28.60	+20.90				
Influence of Δ 9			-110	-110											-110	-110			
		+11	+18.80	+37.50	+35	+37.50	+18.80								+9	+18	+22	+21	+49
	+45	+20	+15.20	+7.00	+10	-5	-10	-8.80	-4.40				+17.50						
											+11.30	+22.50	+20	+19	+22	+11	+10		
			-2.20	-4.30	-4.00	-4.30	-2.20												
		-2.10						-1.10	-2.20	-2.20	-2.50	-1.30	-2.00		-1.70	-3.40	-4.20	-4.00	-9.40
	+2.40	+1.10	+0.80	+0.40		+0.90	+1.80	+1.50											
					+0.60				+0.80		+0.70	+1.30	+1.20	+1.20	+1.30	+0.70	+0.60		
			-0.30	-0.60	-0.60	-0.70	-0.40	-0.30	-0.50	-0.50	-0.50	-0.30	-0.30						
		-0.20													-0.10	-0.20	-0.30	-0.20	-0.60
	+0.30	+0.10	+0.10				+0.40	+0.30	-6.30	-2.70	+9	+0.20	+0.20	+0.10	+0.20				
				-69.40	+41	+28.40													
	+47.70	+29.90	-76.60									+22.44	+36.60	+20.30	-79.30	-83.90	+27.10	+16.80	+39
							+8.40	-8.40											
Influence of Δ 8	-428																		-428
		+42.50																	
															+34.50	+69	+85	+82	+192
	+2.16	+96.50	73	+36.50															
																	+48.30		
			-6.20	-12.40	-11.70	-12.40	-6.20						-5.90						
		-4.80													-3.90	-7.70	-9.60	-9.20	-21.80
	+6.10	+2.80	+2.10	+1.10		+1.70	+3.30	+2.90	+1.50										
					-3.00						-3.30	-6.60	-5.90	-5.80	-6.40	-3.20	+1.40		
	-205.90	+137	+68.90	+0.10	0	+0.10													
								+0.30	+0.60	+0.60	+0.60	+0.30			+0.20	+0.30	+0.40	+0.30	+0.80
				+25.30	-14.70	-10.60	-0.20	-0.10	+2.10	+0.60	-2.70	-0.10	-0.10	-0.10	-0.10	+58.40	+125.50	+73.10	-259
							-3.10	+3.10				-6.40	-11.90	-5.90	+24.20				
Influence of Moment of Above Floor							-7.80		-11.50										
								+1.85	+3.70	+3.70	+4.10	-2.05							
					-0.25	+1.58	+2.15	+2.80	-1.40		-0.28	-0.55	-0.49	-0.47	-0.54	-0.27			
			-0.23	-0.45	-0.43	-0.45	-0.23	-0.18	-0.36	-0.36	-0.40	-0.20	-0.22						
	+0.13	+0.06	+0.04	+0.02	+0.05	+0.11	+0.22	+0.19	+0.10		+0.06	+0.11	+0.10	+0.10	+0.11	+0.06	+0.03		
		+0.02	-0.03	-0.00	-0.06	-0.06	-0.03	-0.03	-0.05	-0.05	-0.06	-0.03	-0.03		+0.02	+0.03	+0.04	+0.03	+0.08
	+0.01	0	0				+0.03	+0.03				+0.01	+0.01	+0.01	+0.01	-0.18	+0.07	+0.03	+0.08
				-0.49	-0.69	+1.18			+4.79	+3.29	+3.42								
	+0.14	+0.08	-0.22				+3.14	+4.66				+1.39	-0.63	-0.36	-0.40				
Final Moments	-1.95					-17.10	-14.40	+14.40	+12.90	+7.05	-19.95	-23.00							-1.38
	+17.20					+10.30	+3.02	-3.02	-2.27	-0.97	+3.24	+8.10							+14.0
	-28.30					+1.45	-0.42	+0.42	+0.29	+0.08	-0.37	-0.88							-35.30
	-13.05					-8.35	-11.90	+11.90	+10.92	+6.16	-17.08	-15.78							-22.58

Checking Results:

$R_1 + R_2 = \frac{13.05 + 22.58}{1.70} = \frac{35.63}{1.70} = 21.20T.$

$\Sigma F_x = 42.45 - 21.20 \times 2 = 0.05T$

∴ OK



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER :	RIAD SHAHIN	WIND ANALYSIS
CHK'D BY :	RIAD SHAHIN	HARDY CROSS METHOD
APP'D BY :	Dr JACK NASSER	DATE : DECEMBER 1964 — SHEET N° 73

10 - 9 - 8 Floors

1. *Shears*

$V8 = \frac{-2}{1.70}(-6.90-4.80) = \frac{-2}{1.70}(-11.70) = +13.70 = +13.70\,\Delta_{10}/10^4$

$V9 = \frac{-2}{3.40}(+10.90+25.40+10.20+20.90) = \frac{-2}{3.40}(+66.40) = -39 = -39\,\Delta_{10}/10^4$

$V10 = \frac{-2}{3.40}(-60.40-50.90-81.30-70.40) = \frac{-2}{3.40}(-263.00) = 154.00 = +154.00\,\Delta_{10}/10^4$

$V8 = \frac{2}{1.70}(+47.70+39) = \frac{-2}{1.70}(+86.70) = -102 = -102\,\Delta_9/10^4$

$V9 = \frac{-2}{3.40}(-76.60-69.40-83.90.74.30) = \frac{-2}{3.40}(-309.20) = +181 = +181\,\Delta_9/10^4$

$V10 = \frac{-2}{3.40}(+28.40+8.40+22.40+9) = \frac{-2}{3.40}(+68.20) = -40 = -40\,\Delta_9/10^4$

$V8 = \frac{-2}{1.70}(-205.90-257) = -\frac{2}{1.70}(-462.90) = +544 = +544\,\Delta_8/10^4$

$V9 = \frac{-2}{3.40}(+68.90+25.30+58.40+24.20) = \frac{-2}{3.40}(+176.80) = -104 = -104\,\Delta_8/10^4$

$V10 = \frac{-2}{3.40}(-10.60-3.10-6.40-2.70) = \frac{-2}{3.40}(-22.80) = +13.40 = 13.40\,\Delta_8/10^4$

2. *Effect of 11th floor.*

$V8 = \frac{-2}{1.70}(+0.14+0.08) = \frac{-2}{1.70}(+0.22) = -0.26$

$V9 = \frac{-2}{3.40}(-0.22-0.49-0.18-0.40) = \frac{-2}{3.40}(-1.29) = +0.75$

$V10 = \frac{-2}{3.40}(+1.18+3.14+1.39+3.42) = \frac{-2}{3.40}(+9.13) = -5.35$

3 *Δ's*

$+13.70\,\Delta_{10} - 102\,\Delta_9 + 544\,\Delta_8 = (42.45-0.26)10^4 = 42.19 \times 10^4$

$-39\,\Delta_{10} + 181\,\Delta_9 - 104\,\Delta_8 = (39.55+0.75)10^4 = 40.30 \times 10^4$

$+154\,\Delta_{10} - 40\,\Delta_9 + 13.40\,\Delta_8 = (36.40-5.35)10^4 = 31.05 \times 10^4$

$\Delta_8 = 0.137$

$\Delta_9 = 0.361$

$\Delta_{10} = 0.283$

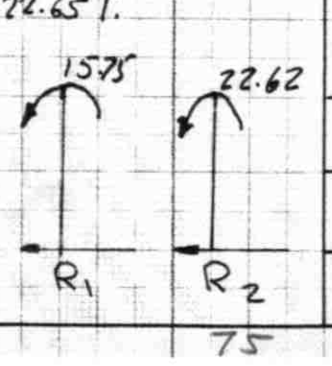
JOINT	7			8			9		9a			8a				7a			
MEMBER	I	R	S	I	R	S	I	R	L	R	I	S	L	R	I	S	L	R	I
DIST. FACTOR	0.47	0.21	0.32	0.46	0.30	0.24	0.53	0.47	0.32	0.32	0.36	0.18	0.23	0.23	0.36	0.26	0.17	0.17	0.40
Influence of Δ 9						-110	-110				-110	-110							
					+12.50	+30.50	+59	+51	+25.80		+10	+20	+25	+25	+40	+20			
			+15.50	+31	+20	+16	+8	+10.30	+20.60	+20.60	+23.30	+11.70							
													+10						
					-2.50	-4.80	-9.70	-8.60	-4.30		-2.00	-3.90	-5.00	-5.00	-7.80	-3.90			
		-1.40						+1											
	-6.60	-3.00	-4.50	-2.30					+2	+2	+2.30	+1.20			-2.10	-4.20	-2.70	-2.70	-6.50
																	-1.50		
			+2.20	+4.40	+2.90	+2.30	+1.20												
													+1.50						
												-0.10	-0.10	-0.20	-0.20	-0.10			
	-1	-0.50	-0.70	-0.40		-0.60	-1.20	-1	-0.50										
																	-0.30		
									+0.1	-0.20	+0.20				+0.30	+0.30	+0.30	+0.30	+0.80
		+0.20																	
			+0.30	+0.50	+0.30	+0.20	+0.10						+0.10			+12.30	-4.20	-2.40	-5.70
							-0.10		+43.40	+22.80	-66.20								
	-0.30	-0.10	-0.10	+33.20	+33.20	-66.40						-0.10	-0.10	-0.10	-0.10				
							-52.70	+52.70											
	-7.90	-4.80	+12.70									-81.20	+31.40	+19.70	+20.10				
Influence of 8			-214	-214											-214	-214			
		+18																	
			+49	+98	+64	+52	+26								+28	+56	+36	+36	+86
													+32						
	+69	+31	+47	+24	+17.50						+14	+28	+35	+35	+56	+28			
																	+15.50		
			-9.50	-19	-12.50	-10	-5								-5.70	-11.40	-7.40	-7.40	-17.30
		-3.70				-5.50	-11	-10	-5				-6.30						
											+1.10								
	+6.20	+2.80	+4.20	+2.20	+1.40			-1.60	-3.20	-3.20	-3.70	+2.20	-2.80	+2.70	+4.30	+2.20	+1.40		
												-1.90							
		-0.30	+0.50	+0.90	+0.60	+0.40	+0.20								-0.50	-0.90	-0.60	-0.60	-1.00
													+0.30						
					+0.20	+0.40	+0.70	+0.70	+0.40		+0.20	+0.40	+0.50	+0.50	+0.70	+0.40			
			-0.10	-0.20	-0.20	-0.20			-0.20	-0.20	-0.20					-0.10	-0.10	-0.10	-0.10
	-0.10	0	0				+10.90	-10.90											
	+75.10	+47.80	-122.90	-108.20	+71.10	+37.10			-8	-3.40	+11.40	+28.70	+64.30	+38.20	-131.20	-139.80	+144.80	+27.90	+67.10
Influence of Δ 7	-428																		-428
		+36.50																	
	+184.50	+82	+25	+62.50											+55.50	+111	+73	+73	+171
				-29.00	-18.50	-15	-7.50										+41		
			-14.50																
													-9.30						
					-5.30	+2	+4	+3.50	+1.80		-4.20	-8.40	-10.60	-10.60	-16.60	-8.30			
		-2.80																	
															-4.30	-8.50	-5.50	-5.60	-13.10
	+8.10	+3.60	+5.60	+2.80															
					+0.50						+0.40	+0.80	+1.00	+1.00	+1.50	+0.80	+1.80		
		-0.30						+0.30	+0.60	+0.70	+0.70	+0.40			-0.40	-0.70	-0.50	-0.50	-0.90
	+0.10	+0.10	+0.10	0	0	0	-0.20	-0.10				0	0	0	0				
	-235.30	+119.10	+116.20	+36.30	-23.30	-13	-3.70	+2.70	+2.40	+0.70	-3.10	-7.20	-18.90	-9.60	+35.70	+91.30	+109.80	+66.90	-271
Influence of Moment of Above Floor							-8.35			-15.78									
								+2.52	+5.04	+5.04	+5.70	+2.85							
						+1.55	+3.10	+2.73	+1.37		-0.26	-0.51	-0.66	-0.66	-1.02	-0.52			
					-0.33														
			-0.28	-0.56	-0.37	-0.29	-0.15	-0.18	-0.36	-0.35	-0.40	-0.20	-0.19		+0.07	+0.14	+0.09	+0.08	+0.21
		+0.05																	
	+0.11	+0.05	+0.07	+0.04	+0.04	+0.09	+0.8	+0.15	+0.08		+0.03	-0.06	+0.07	+0.07	+0.12	+0.06	+0.03		
																-0.02	-0.02	-0.02	-0.03
		-0.01	-0.02	-0.08	-0.05	-0.04	-0.02	-0.02	-0.04	-0.03	-0.04	-0.02	-0.03						
	+0.02	+0.00	+0.01				+0.02	+0.02				+0.01	+0.01	+0.10	+0.02	-0.34	+0.10	+0.06	+0.18
				-0.60	-0.71	+1.31													
	+0.13	+0.09	-0.22				+3.13	+5.22	+6.09	+46.6	+5.03	+2.19	-0.80	0.58	0.81				
Final Moments	-2.25					-18.80	-14.90	+14.90	+12.30	+6.45	-18.75	-23							-1.62
	+2.70					+10.30	+3.00	-3.00	-2.22	-0.94	+3.16	+79.5							+18.56
	-34.20					-1.85	-0.50	+0.54	+0.35	+0.10	-0.45	-1.05							-39.50
	-15.75					-10.35	-12.44	+12.44	+10.43	+5.61	-16.04	-16.10							-22.62

Checking Results:

$R_1 + R_2 = \frac{15.75 + 22.62}{1.70} = \frac{38.37}{1.70} = 22.65\,T.$

$\Sigma F_x = 45.35 - 2 \times 22.65 = 0.05\,T.$

∴ OK



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER :	RIAD SHAHIN	WIND ANALYSIS	
CHK'D BY :	RIAD SHAHIN	HARDY CROSS METHOD	
APP'D BY :	Dr JACK NASSER	DATE ; DECEMBER 1964	SHEET Nº 75

9 - 8 - 7 Floors

1. *Shears*

$V_7 = \frac{-2}{1.70}(-7.90-5.70) = \frac{-2}{1.70}(-13.60) = +16 = +16\Delta_9/10^4$

$V_8 = \frac{-2}{3.40}(+12.70+33.20+12.30+30.10) = \frac{-2}{3.40}(+88.30) = -52 = -52\Delta_9/10^4$

$V_9 = \frac{-2}{3.40}(-66.40-52.70-81.20-66.20) = \frac{-2}{3.40}(-266.50) = +157 = +157\Delta_9/10^4$

$V_7 = \frac{-2}{1.70}(+75.10+67.10) = \frac{-2}{1.70}(+142.20) = -167 = -167\Delta_8/10^4$

$V_8 = \frac{-2}{3.40}(-108.80-122.90-139.80-131.20) = \frac{-2}{3.40}(-503.10) = +296 = +296\Delta_8/10^4$

$V_9 = \frac{-2}{3.40}(+37.10+10.90+28.70+11.40) = \frac{-2}{3.40}(+88.10) = -51.80 = -51.80\Delta_8/10^4$

$V_7 = \frac{-2}{1.70}(-235.30-271.00) = \frac{-2}{1.70}(-506.30) = +592 = +592\Delta_7/10^4$

$V_8 = \frac{-2}{3.40}(+116.20+36.30+94.30+35.70) = \frac{-2}{3.40}(+282.50) = 166 = -166\Delta_7/10^4$

$V_9 = \frac{-2}{3.40}(-13.00-3.70-7.20-3.10) = \frac{-2}{3.40}(-27.00) = +15.90 = +15.90\Delta_7/10^4$

2. *Effect of 10th Floor.*

$V_7 = \frac{-2}{1.70}(+0.13+0.18) = \frac{-2}{1.70}(+0.31) = -0.36$

$V_8 = \frac{-2}{3.40}(-0.22-0.60-0.34-0.81) = \frac{-2}{3.40}(-1.97) = +1.26$

$V_9 = \frac{-2}{3.40}(+1.31+3.13+2.19+5.03) = \frac{-2}{3.40}(+11.66) = -6.85$

3 *Δ's*

$+16\Delta_9 - 167\Delta_8 + 592\Delta_7 = (45.35-0.36)10^4 = 44.99 \times 10^4$

$-52\Delta_9 + 296\Delta_8 - 166\Delta_7 = (42.45+1.26)10^4 = 43.71 \times 10^4$

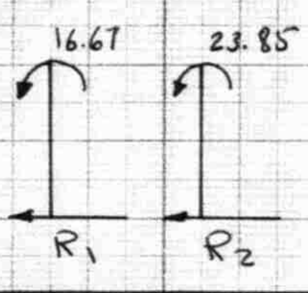
$+157\Delta_9 - 51.80\Delta_8 + 15.90\Delta_7 = (39.55-6.85)10^4 = 32.70 \times 10^4$

$\Delta_7 = 0.145$

$\Delta_8 = 0.278$

$\Delta_9 = 0.284$

JOINT	6			7			8		8a			7a				6a			
MEMBER	I	R	S	I	R	S	I	R	L	R	I	S	L	R	I	S	L	R	I
DIST FACTOR	0.47	0.21	0.32	0.38	0.24	0.38	0.61	0.39	0.29	0.27	0.44	0.30	0.20	0.20	0.30	0.20	0.17	0.17	0.40
Influence of Δ 8						-214	-214				-214	-214							
					+21.50	+65	+130	+84	+42		+32	+64	+43	+43	+64	+32			
			+24.30	+48.50	+30.50	+48.50	+24.30	+20.50	+41	+38	+61	+30.50			-4.20	-8.30	-5.40	-5.40	-12.90
		-2.70											+5.30						
					-4.20	-13.60	-27.20	-17.60	-8.80		-6.20	-12.40	-8.40	-8.40	-12.40	-6.20			
			+3.40	+6.80	+4.20	+6.80	+3.40	+2.20	+4.40	+4.00	+6.60	+3.20	+2.10						
	-11.70	-5.30	-8.00	-4.00													-2.70		
															+1.20	+2.30	+1.50	+1.50	+3.60
		+0.80			-0.70						-1	-2.50	-1.30	-1.30	-1.90	-1			
			+0.90	+1.80	+1.10	+1.80	+0.90						+0.60						
						-2	-4.00	-9.50	-1.30										
			+1.40	+0.70	+0.60	+0.70	+0.40	+0.30	+0.70	+0.60	+1	+0.50	+0.30						
	-1.00	-0.50	-0.60	-0.30	-0.20		-0.40	-0.30				-0.40	-0.30	-0.30	-0.40	-0.20	-0.20		
									+78	+42.60	-120.60								
	-12.70	-7.70	+20.40	+0.20	+0.10	+0.20	-86.60	+86.60				-130.60	+51.30	+33	+46.30	+0.90	+0.20	+0.30	+0.60
				+53.70	+52.90	-106.60										+19	-6.70	-3.60	-8.70
Influence of Δ 7			-214	-214											-214	-214			
		+18	+40.50	+81	+52	+81	+40.50								+28	+58	+36	+36	+86
													+2.6						
	+73	+32.50	+50	+25	+16						+24	+48	+32	+32	+48	+24	+16.30		
		-3.50	-7.80	-15.50	-10	-15.50	-7.80								-5.20	-10.40	-6.90	-6.90	-16.10
													-5.00						
	+5.30	+2.40	+3.60	+1.80		-10	-20	-12.70	-6.40										
								-2.60	-5.10	-4.70	-7.80	-3.80					+1.20		
					+1.40						+2.10	+4.20	+2.80	+2.80	+4.20	+2.10			
			+1.30	+2.60	+1.60	+2.60	+1.70												
		-0.30				+0.40	+0.70	+0.50	+0.30				+0.80		-0.40	-0.80	-0.60	-0.60	-1.30
	-0.50	-0.20	-0.36	-0.20		-0.20		-0.30	-0.70	-0.60	-1.10	-0.60							
							+0.20	+0.10				-0.10	0	0	+0.10	-143.10	+46	+28.50	+68.60
									-11.90	-5.30	+17.20								
	+77.80	+48.90	-126.70	-110.30	+61	+58.70	+15	-15				+47.00	+56.60	+34.80	-139.30				
Influence of Δ 6	-428																		-428
		+36.50													+55.50	+111	+73	+73	+171
	+184	+82	+125.50	+62.70															
																	+41		
			-11.90	-23.80	-15.20	-23.80	-11.90						-7.60						
											-7.10	-14.20	-9.60	-9.60	-14.40	-7.20			
		2.00			-4.80	+3.70	+7.30	+4.60	+2.30										
	+7	+3.00	+4.80	+2.40											-4.40	-8.80	-5.70	-5.80	-13.50
								+0.70	+1.40	+1.80	+2.10	+1.00							
			-0.30	-0.50	-0.30	-0.50	-0.30						-0.20				+1.60		
					+0.40		-0.20	-0.20			+0.50	+1.00	+0.80	+0.80	+1.00	+0.50			
		-0.20							-0.20	-0.10	-0.20				-0.30	-0.50	-0.40	-0.40	-0.80
	+0.20	+0.10	+0.20	+0.10			-5.10	+5.10				+0.10	+0.10		+0.10				
				0.20	-0.10	-0.20			+3.50	+1.20	-4.70					+95	+109.50	+66.80	-271.30
	-236.80	+118.50	+118.30	+40.80	-20	-20.80						-12.20	-16.50	-8.80	+37.50				
Influence of Moment of Above floor							-10.35		-16.10										
								+2.33	+4.65	-4.35	+7.10	+3.55							
					-0.36	+2.45	+4.90	+3.12	+1.56		-0.53	-1.06	-0.71	-0.72	-1.06	-0.53			
		+0.05	-0.40	-0.74	-0.50	-0.80	-0.40	-0.15	-0.30	-0.28	-0.45	-0.23			+0.07	+0.14	+0.09	+0.09	+0.21
													-0.25						
					+0.04	+0.17	+0.34	+0.21	+0.11		+0.06	+0.12	+0.08	+0.09	+0.12	+0.06			
			-0.04	-0.08	-0.05	-0.08	-0.04	-0.03	-0.05	-0.05	-0.07	-0.03	-0.03						
	+0.19	+0.09	+0.12	+0.06			+0.04	+0.03									+0.05		
				-0.02	-0.02	-0.02			+5.97	+4.02	+6.11				-0.01	-0.03	-0.02	-0.02	-0.04
	+0.18	+0.14	-0.32				+4.84	+5.51				+0.02	+0.02	+0.02	+0.02				
				-0.83	-0.89	+1.72						+2.37	-0.80	-0.61	-0.87	-0.36	+0.10	+0.07	+0.17
Final Moments	-2.57					-21.50	-17.50	+17.50	+15.70	+8.80	-24.50	-26.30							-1.75
	+22.40					+16.70	+4.30	-4.30	-3.43	-1.57	+4.95	+13.70							+10.70
	-36.50					-3.20	-0.78	+0.78	+0.54	+0.17	-0.72	-1.87							-41.80
	16.67					-7.90	-13.98	-13.98	+12.81	+7.46	-20.27	-14.47							-23.85



Checking Results:

$R_1 + R_2 = \frac{16.67 + 23.85}{1.70} = \frac{40.52}{1.70} = 24$

$\Sigma F_x = 48.10 - 2 \times 24 = 0.10\,T$

∴ O.K.

ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER :	RIAD SHAHIN	WIND ANALYSIS
CHK'D BY :	RIAD SHAHIN	HARDY CROSS METHOD
APP'D BY :	Dr. JACK NASSER	DATE : DECEMBER 1964 — SHEET No 77 /

8 - 7 - 6 Floors

1. *Shears*

$V_6 = \frac{-2}{1.70}(-12.70-8.70) = \frac{-2}{1.70}(-21.40) = +25.20 = +25.20\Delta_8/10^4$

$V_7 = \frac{-2}{3.40}(+20.40+53.70+19+46.30) = \frac{-2}{3.40}(+139.40) = -82 = -82\Delta_8/10^4$

$V_8 = \frac{-2}{3.40}(-106.60-86.60-130.60-120.60) = \frac{-2}{3.40}(-444.40) = +260 = +260\Delta_8/10^4$

$V_6 = \frac{-2}{1.70}(+77.80+68.60) = \frac{-2}{1.70}(+146.40) = -172 = -172\Delta_7/10^4$

$V_6 = \frac{-2}{3.40}(-126.70-119.30-143.10-139.30) = \frac{-2}{3.40}(-528.40) = +310 = +310\Delta_7/10^4$

$V_8 = \frac{2}{3.40}(+58.30+15+47.90+17.20) = \frac{-2}{3.40}(+138.40) = -80 = -80\Delta_7/10^4$

$V_6 = \frac{-2}{1.70}(-236.80-271.30) = \frac{-2}{1.70}(-508.10) = +595 = +595\Delta_6/10^4$

$V_7 = \frac{-2}{3.40}(+118.30+40.80+95.00+37.50) = \frac{-2}{3.40}(+291.60) = 171 = -171\Delta_6/10^4$

$V_8 = \frac{-2}{3.40}(-20.80-5.10-12.30-4.70) = \frac{-2}{3.40}(-42.80) = +25.20 = +25.20\Delta_6/10^4$

2. *Effect of 9th floor.*

$V_6 = \frac{-2}{1.70}(+0.18+0.17) = \frac{-2}{1.70}(+0.35) = -0.41$

$V_6 = \frac{-2}{3.40}(-0.32-0.83-0.36-0.87) = \frac{-2}{3.40}(-2.38) = +1.40$

$V_7 = \frac{-2}{3.40}(+1.72+4.84+2.37+6.11) = \frac{-2}{3.40}(+15.04) = -8.70$

3. *Δ's*

$+25.20\Delta_8 - 172\Delta_7 + 595\Delta_6 = (48.10-0.41)10^4 = 47.69\times10^4$

$-82\Delta_8 + 310\Delta_7 - 171\Delta_6 = (45.35+1.40)10^4 = 46.75\times10^4$

$+260\Delta_8 - 80\Delta_7 + 25.20\Delta_6 = (42.45-8.70)10^4 = 33.75\times10^4$

$\Delta_6 = 0.154$

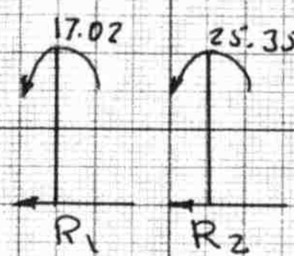
$\Delta_7 = 0.288$

$\Delta_8 = 0.202$

JOINT	5			6			7		7a			6a				5a			
MEMBER	I	R	S	I	R	S	I	R	L	R	I	S	L	R	I	S	L	R	I
DIST. FACTOR	0.47	0.21	0.32	0.38	0.24	0.38	0.61	0.39	0.29	0.27	0.44	0.30	0.20	0.20	0.30	0.26	0.17	0.17	0.40
Moment of Above Floor							-7.90		-14.47										
								+2.10	+4.20	+3.90	+6.31	+3.19							
						+1.77	+3.54	+2.26	+1.13										
					-0.32						-0.48	-0.95	-0.64	-0.64	-0.96	-0.48			
		+0.04	-0.28	-0.55	-0.35	-0.55	-0.28	-0.10	-0.19	-0.17	-0.29	-0.15	-0.18		+0.06	+0.13	+0.08	+0.08	+0.19
	+0.11	+0.05	+0.08	+0.04	+0.03	+0.12	+0.23	+0.15	+0.08		+0.04	+0.08	+0.05	+0.06	+0.08	+0.04	+0.03		
																-0.02	-0.01	-0.01	-0.03
			-0.04	-0.07	-0.05	-0.07	-0.07	-0.02	-0.04	-0.03	-0.05	-0.03	-0.03						
	+0.02	+0.01	+0.01				+0.05	+0.04				+0.02	+0.01	+0.01	+0.02	-0.33	+0.10	+0.07	+0.16
									+5.18	+3.70	+5.59								
	+0.13	+0.10	-0.23	-0.58	-0.69	+1.27	+3.47	+4.43				+2.16	-0.79	-0.57	-0.80				
Final Moments	-2.82					-23.80	-19.40	+19.40	+17.50	+9.50	-27	-29.20							-1.95
	+23.80					+18.00	+4.60	-4.60	-3.60	-1.65	+5.30	+14.70							+21.00
	40.00					-3.40	-0.84	+0.84	+0.58	+0.20	-0.78	-2.00							-4.50
	-17.02					-9.20	-15.60	+15.60	+14.43	+8.05	-22.18	-16.50							-25.95

Checking Results

$R_1 + R_2 = \frac{17.02 + 25.95}{1.70} = \frac{42.97}{1.70} = 25.30\,T$



$\Sigma F_x = 50.70 - 25.30 \times 2 = 0.10\,T$

∴ OK

ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER : RIAD SHAHIN	WIND ANALYSIS	
CHK'D BY : RIAD SHAHIN	HARDY CROSS METHOD	
APP'D BY : Dr. JACK NASSER	DATE : DECEMBER 1964	SHEET No. 79

7 - 6 - 5 Floors

1. Shears (same as previous case)

2. Effect of 8th floor

$V_5 = \frac{-2}{1.70}(+0.13+0.16) = \frac{-2}{1.70}(+0.29) = -0.34$

$V_6 = \frac{-2}{3.40}(-0.23-0.58-0.33-0.80) = \frac{-2}{3.40}(-1.94) = +1.14$

$V_7 = \frac{-2}{3.40}(+1.27+3.47+2.16+5.59) = \frac{-2}{3.40}(+12.49) = -7.35$

3. Δ's

$+25.20\Delta_7 - 172\Delta_6 + 595\Delta_5 = (50.70-0.34)10^4 = 50.36\times10^4$

$-82\Delta_7 \quad +310\Delta_6 - 171\Delta_5 = (48.10+1.14)10^4 = 49.24\times10^4$

$+260\Delta_7 - 80\Delta_6 + 25.20\Delta_5 = (45.35-7.35)10^4 = 38.00\times10^4$

$\Delta_5 = 0.165$

$\Delta_6 = 0.308$

$\Delta_7 = 0.224$

JOINT	4			5			6		6a			5a				4a			
MEMBER	I	R	S	I	R	S	I	R	L	R	I	S	L	R	I	S	L	R	I
DIST FACTOR	0.58	0.20	0.22	0.38	0.24	0.38	0.61	0.39	0.29	0.27	0.44	0.30	0.20	0.20	0.30	0.19	0.17	0.16	0.48
Influence of Δ 6						-214	-214				-214	-214							
					+21.50	+65	+1.30	+84	+42		+32	+64	+43	+43	+64	+32			
		-2.70	+24.30	+48.50	+30.50	+47.50	+24.30	+20.50	+41						-3.00	-6.10	-5.40	-5.10	-15.40
										+38	+61	+30.50	+15.30						
	-12.50	-4.30	-4.80	-2.40	-4.30	-13.70	-77.40	-17.40	-8.70		-6.40	-12.80	-8.60	-8.60	-12.80	-6.40	-2.20		
			+3.80	+7.80	+4.80	+7.80	+3.80	+2.20	+4.40	+4.10	+6.60	+3.30	+2.40		+0.80	+1.60	+1.50	+1.40	+4.10
		+0.80																	
	-2.70	-0.90	-1	-0.50	-0.70	-1.80	-3.60	-2.40	-1.20		-1	-2.00	-1.30	-1.30	-1.90	-1	-0.50		
			+0.60	+1.20	+0.70	+1.10	+0.60	+0.30	+0.60	+0.60	+1	+0.50	+0.47		+0.20	+0.30	+0.30	+0.30	+0.60
		+0.20									-0.20								
	-0.40	-0.20	-0.20	-0.10	-0.10	-0.30	-0.50	-0.42	-0.20			-0.30	-0.20	-0.30	-0.30	-0.20	-0.40		
				+0.20	+0.10	+0.2			+0.10	+0.10	+0.20					+0.10			+0.20
	-15.60	-7.10	+22.70				-86.80	+86.60				-110.80	+51.00	+33.00	+46.80				
				+54.70	+52.50	-107.20			+78	+42.80	-120.80					+20.30	-6.60	-3.40	-10.30
Influence of Δ 5			-214	-214											-214	-214			
		+18	+40.50	+81	+52	+81	+40.50								+20.50	+41	+36	+34	+103
													+26						
	+90	+31	+34.50	+17.30	+16.90	-12.30	-24.50	-16	-8		+2.5	+50	+33.80	+33.70	+50.50	+2.5	+15.50		
		-3.50	-4.20	-8.30	-5.30	-8.30	-4.20	-2.50	-5.00	-4.50	-7.50	-3.80			-3.80	-7.70	-6.90	-6.50	-19.40
													-2.70						
	+4.40	+1.60	+1.70	+0.90	+1.10	+0.10	+4.10	+2.60	+1.30		+1.60	+3.10	+2.10	-2.00	+3.10	+1.60	+0.80		
			-0.60	-1.50	-1.00	-1.60	-0.80	-0.40	-0.80	-0.70	-1.40	-0.70	-0.50		-0.20	-0.50	-0.40	-0.30	-1.20
		-0.20																	
	+0.60	+0.20	+0.20	+0.10	+0.20	+0.30	+0.70	+0.50	+0.20		+0.20	+0.40	+0.30	+0.30	+0.40	+0.20	+0.10		
	+95.00	+47.10	-142.10	-0.20	-0.20	-0.20	+15.80	-15.80	-0.20		-0.20	+49	+59	+36.00	-144	-0.10			-0.20
				-124.70	+63.70	+6			-12.50	-5.20	+17.70					-154.50	+45.10	+27.20	+82.20
Influence of Δ 4																			-740
	-740														+70.50	+141	+12.6	+118	+355
		+63																	
	+3.92	+135	+150	+75													+62.50		
			-14.30	-28.50	-18	-28.50	-14.30						-9						
							+8.70	+5.60	+2.80		-9.20	-18.40	-12.30	-12.30	-18.50	-9.30			
					-6.20	+4.30													
		-4.50						+100	+1.90	+1.70	+2.80	+1.40			-5.10	-10.10	-9.00	-8.50	-25.60
	+10.90	+3.80	+4.10	+2.10															
					+0.40						+0.60	+1.10	+0.80	+0.70	+1.10	+0.60	+1.90		
			-0.10	-0.20	-0.20	-0.20	-0.10						-0.10		-0.30	-0.50	-0.40	-0.40	-1.20
		-0.20																	
	+0.20	0	+0.10			-0.30	-0.50	-0.40	-0.20										
									-0.10	-0.10	-0.20	-0.10				+127.70	+181	+109.10	-411.80
				+0.10	+0.10	+0.10													
	-336.90	+197.10	+139.80				-6.20	+6.20	+4.40	+1.60	-6.00	+0.20	+0.10	+0.10	+0.20				
				+48.50	-23.90	-24.60						-15.90	-20.50	-11.50	+47.90				
Influence of Moment of Above floor								-9.20		+16.50									
								+2.40	+4.80	+4.45	+7.25	+3.63							
					-0.36	+2.07	+4.14	+2.66	+1.33		-0.54	-1.09	-0.72	-0.73	-1.09	-0.54			
		+0.05	-0.33	-0.65	-0.41	-0.65	-0.33	-0.12	-0.23	-0.21	-0.35	-0.18	-0.2		+0.05	+0.10	+0.00	+0.09	+0.26
	+0.16	+0.06	+0.06	+0.03	+0.03	+0.14	+0.27	+0.18	+0.09		+0.05	+0.10	+0.07	+0.07	+0.10	+0.05	+0.03		
			-0.03	-0.07	-0.06	-0.07	-0.04	-0.02	-0.04	-0.04	-0.06	-0.03	-0.03						
	+0.01	+0.01	+0.01				+0.04	+0.02				+0.02	+0.01	+0.01	+0.02	-0.02	-0.02	-0.02	-0.02
				-0.69	-0.80	+1.49			+5.95	+4.20	+6.35								
	+0.17	+0.12	-0.29				+4.08	+5.12				+2.45	-0.88	-0.65	0.92	-0.91	+0.10	+0.57	+0.24
Final Moments	-3.55					-24.30	-19.70	+19.70	+17.70	+9.70	-27.45	-29.70							-2.35
	+26.60					+17.20	+4.43	-4.43	-3.50	-1.45	+4.95	+13.70							+23.00
	-39.80					-2.90	-0.73	+0.73	+0.52	+0.19	-0.71	-1.82							-48.80
	-16.75					-10.00	-16	+16	+14.72	+8.44	+23.16	-17.87							-28.15

Checking Results.

$R_1 + R_2 = \frac{16.75 + 28.15}{1.70} = 26.60\,T.$

$\Sigma F_x = 53.30 - 26.60 \times 2 = 0.10\,T.$

∴ O.K.

16.75 28.15

R_1 R_2

ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER : RIAD SHAHIN	WIND ANALYSIS	
CHK'D BY : RIAD SHAHIN	HARDY CROSS METHOD	
APP'D BY : Dr. JACK NASSER	DATE : DECEMBER 1964	SHEET No. 81 /

6 - 5 - 4 Floors

1. Shears

$V_4 = \frac{-2}{1.70}(-15.60-10.30) = \frac{-2}{1.70}(-25.90) = +30.50 = +30.50\Delta_6/10^4$

$V_5 = \frac{-2}{3.40}(+22.70+54.70+20.30+46.80) = \frac{-2}{3.40}(+144.50) = -85 = -85\Delta_6/10^4$

$V_6 = \frac{-2}{3.40}(-107.20-86.80-130.80-120.80) = \frac{-2}{3.40}(-445.60) = +262 = 262\Delta_6/10^4$

$V_4 = \frac{-2}{1.70}(+95.00+82.20) = \frac{-2}{1.70}(+177.20) = -208 = -208\Delta_5/10^4$

$V_5 = \frac{-2}{3.40}(-142.10-124.70-154.50-144.00) = \frac{-2}{3.40}(-565.30) = +332 = 332\Delta_5/10^4$

$V_6 = \frac{-2}{3.40}(+61+15.80+49+17.70) = \frac{-2}{3.40}(+143.50) = -84.20 = -84.20\Delta_5/10^4$

$V_4 = \frac{-2}{1.70}(-336.90-411.80) = \frac{-2}{1.70}(-748.70) = +880 = +880\Delta_4/10^4$

$V_5 = \frac{-2}{3.40}(+139.80+48.50+181.70+47.90) = \frac{-2}{3.40}(+357.90) = -210 = -210\Delta_4/10^4$

$V_6 = \frac{-2}{3.40}(-24.60-6.20-15.90-6.00) = \frac{-2}{3.40}(-52.70) = +31 +31\Delta_4/10^4$

2. Effect of 7th floor

$V_4 = \frac{-2}{1.70}(+0.17+0.24) = \frac{-2}{1.70}(+0.41) = -0.48$

$V_5 = \frac{-2}{3.40}(-0.29-0.69-0.41-0.92) = \frac{-2}{3.40}(-2.31) = +1.38$

$V_6 = \frac{-2}{3.40}(+1.49+4.08+2.45+6.35) = \frac{-2}{3.40}(+143.7) = -8.45$

3. Δ's

$+30.50\Delta_6 - 208\Delta_5 + 880\Delta_4 = (53.30-0.48)10^4 = 52.82\times10^4$

$-85\Delta_5 + 332\Delta_5 - 210\Delta_4 = (50.70+1.38)10^4 = 49.32\times10^4$

$+262\Delta_6 - 84.20\Delta_5 + 31\Delta_4 = (48.10-8.45)10^4 = 39.65\times10^4$

$\Delta_4 = 0.118$

$\Delta_5 = 0.281$

$\Delta_6 = 0.227$

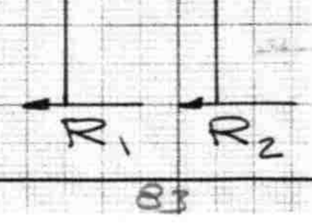
JOINT	3			4			5		52			42				32			
MEMBER	I	R	S	I	R	S	I	R	L	R	I	S	L	R	I	S	L	R	I
DIST FACTOR	0.50	0.17	0.33	0.48	0.24	0.28	0.61	0.39	0.29	0.27	0.44	0.22	0.20	0.19	0.39	0.28	0.15	0.15	0.42
Influence of Δ 15						-214	-214				-214	-214							
					+21.50	+65	+130	+84	+42		+23.50	+47	+43	+41	+83	+41.50			
			+30.50	+61	+30.50	+36	+18	+21.50	+43	+40	+65.50	+32.80	+15.30						
	-15.30	-5.20	-10.00	-5	-4.80	-12	-24	-15.50	-7.80		-5.30	-10.60	-9.60	-9.20	-18.70	-9.40	-2.60		
		-2.20	+5.30	+10.50	+5.20	+6.10	+3.10	+1.90	+3.80	+3.60	+5.70	+2.90	+2.60		-4.10	-8.20	-4.40	-4.40	-12.60
	-1.60	-0.50	-1.00	-0.50	-0.20	-1.50	-3.10	-2.00	-1.50			-0.30	-0.20	-0.20	-0.40	-0.20	-0.30		
			+0.50	+1.00	+0.50	+0.60	+0.30	+0.20	+0.40	+0.40	+0.70	+0.40	+0.30			-0.20			
	-0.30	-0.10	-0.10				-0.30	-0.20	+79.90	+44	-123.90	-0.20	-0.10	-0.10	-0.30	+0.20	+0.10	+0.10	+0.30
				+67	+52.70	-119.70													
	-17.20	-8.00	+25.20				-89.90	+89.90				-142	+51.00	+31.50	+59.50	+23.70	-7.20	-4.30	-12.20
Influence of Δ 4			-370	-370											-370	-370			
		+28	+89	+178	+89	+103	+51.50						+44.50		+51.50	+103	+56	+56	+155
	+126	+43	+84	+42	+27.50						+30	+60	+55	+52	+107	+53.50	+21.50		
		-5.60	-16.70	-33.30	-16.70	-19.50	-9.80						-8.40		-10.50	-21	-11.20	-11.20	-31.60
	+11.20	+3.80	+7.30	+3.70		-12.70	-25.40	-16.30	-8.20								+1.90		
								-3.20	-6.30	-5.90	-9.60	-4.80							
					+2.40						+2.60	+5.20	+4.80	+4.50	+9.20	+4.60			
		-0.50	+1.60	+3.20	+1.60	+1.80	+0.90								-0.90	-1.80	-1.00	-1.00	-2.70
						+0.70	+1.40	+0.90	+0.50				+0.80						
	-0.60	-0.20	-0.30	-0.20													-0.10		
								-0.40	-0.90	-0.80	-1.40	-0.79							
					+0.10						-0.10	+0.20	+0.20	+0.20	+0.20	+0.10			
			-0.20	-0.30	-0.20	-0.10					+0.10								
	+0.20	0	0				+0.20	+0.20							-0.40	0	0	0	
				-176.90	+103.70	+73.20													
	+136.80	+68.50	-205.30				+18.80	-18.80	-14.90	-6.70	+2.16	+59.90	+96.90	+56.70	-213.50	-231.60	+67.10	+43.80	-120.70
Influence of Δ 3	-740																		-740
		+55.50													+103.50	+207	+111	+111	+311
	+342.50	+116	+226	+113															
					-10.30						-11.30	-22.60	-20.60	-19.60	-40.70	-20.40	+58		
			-24.60	-49.20	-24.60	-28.90	-14.50												
	+12.30	+4.20	+8.10										-12.30				+2.10		
				+4.10		+4.40	+8.80	+5.70	+2.80						-5.60	-11.10	-5.90	-6.00	-16.70
		-3.00																	
					+1.80						+1.90	+3.90	+3.60	+3.40	+7.60	+3.50			
			-2.40	-4.90	-2.50	-2.90	-1.40												
								+1.00	+1.90	+1.80	+2.90	+1.50	-1.20						
	+2.70	+0.90	+1.80	+0.90													+0.50		
						+0.10	+0.20	+0.20							-0.60	-1.20	-0.60	-0.60	-1.60
		-0.30	-0.20	-0.50	-0.20	-0.30	-0.10		+4.70	+1.80	-6.50	0.10	0	0	+0.20				
	+0.20	+0.10	+0.20	+63.40	-35.80	-27.60	+0.10	0								+177.80	+165.0	+104.40	-447.30
												-17.20	-30.50	-16.20	+63.90				
	-382.30	+173.40	-208.90				-6.90	+6.90											
Influence of Moment of Above Floor							-10.00			-17.87									
								+2.60	+5.20	+4.82	-7.85	+3.93							
						+2.25	+4.50	+2.90	+1.45		-0.43	-0.86	-0.78	-0.75	-1.54	-0.77			
		+0.06	-0.54	-1.08	-0.54	-0.63	-0.32	-0.15	-0.30	-0.28	-0.45	-0.23	-0.27		+0.11	+0.22	+0.12	+0.11	+0.32
	+0.24	+0.08	+0.16	+0.08	+0.04	+0.14	+0.28	+0.19	+0.10		+0.05	+0.09	+0.08	+0.07	+0.15	+0.08	+0.04		
			-0.07	-0.13	-0.06	-0.07	-0.04	-0.02	-0.04	-0.04	-0.07						-0.03		
		-0.01		-1.13	-0.56	+1.69	+0.03	+0.03				+2.93	-0.97	-0.68	-1.28	-0.03	-0.02	-0.01	-0.03
	+0.04	+0.02	+0.02						+6.42	+4.50	+6.95								
							+4.45	+5.55								-0.50	+0.10	+0.11	+0.29
	+0.28	+0.15	-0.43																
Final Moments	-3.72					-26.10	-19.60	+19.60	+17.40	+9.60	-27.00	-31							-2.68
	+32.00					+17.30	+4.45	-4.45	-3.56	-1.58	+5.08	+14.10							+28.30
	-46.60					-3.45	-0.85	+0.85	+0.58	+0.22	-0.80	-2.10							-54.50
	-18.32					-12.25	-16	+16	+14.48	+8.24	-22.72	-19.00							-28.88

Checking Results:

$R_1 + R_2 = \frac{18.32 + 28.88}{1.70} = \frac{47.20}{1.70} = 27.80$

$\Sigma F_x = 55.70 - 2 \times 27.80 = 0.10T.$

$\therefore$ O.K.



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER : RIAD SHAHIN	WIND ANALYSIS	
CHK'D BY : RIAD SHAHIN	HARDY CROSS METHOD	
APP'D BY : Dr. JACK NASSER	DATE : DECEMBER 1964	SHEET No 83

83

5 - 4 - 3 Floors

1. *Shears*

$V3 = -\frac{2}{1.70}(-17.20-12.20) = \frac{-2}{1.70}(-29.40) = +34.60 = +34.60\Delta 5/10^4$

$V4 = \frac{-2}{3.40}(+25.20+67.00+23.70+59.50) = \frac{-2}{3.40}(+175.40) = -103 = -103\Delta 5/10^4$

$V5 = \frac{-2}{3.40}(-119.70-89.90-142.00-123.90) = \frac{-2}{3.40}(-475.50) = +280 = +280\Delta 5/10^4$

$V3 = -\frac{2}{1.70}(+136.80+120.70) = \frac{-2}{1.70}(+257.50) = -303 = -303\Delta 4/10^4$

$V4 = \frac{-2}{3.40}(-205.30-176.90-231.60-213.50) = \frac{-2}{3.40}(-827.30) = +485 = +485\Delta 4/10^4$

$V5 = \frac{-2}{3.40}(+73.20+18.80+59.90+21.60) = \frac{-2}{3.40}(+173.50) = -102 = -102\Delta 4/10^4$

$V3 = \frac{-2}{1.70}(-382.30-447.30) = \frac{-2}{1.70}(-829.60) = +975 = +975\Delta 3/10^4$

$V4 = \frac{-2}{3.40}(+208.90+63.40+177.80+63.90) = \frac{-2}{3.40}(+514.00) = -302 = -302\Delta 3/10^4$

$V5 = \frac{-2}{3.40}(-27.60-6.90-17.20-6.50) = -\frac{2}{3.40}(-58.20) = +34.30 = +34\Delta 3/10^4$

2. *Effect of 6 th floor*

$V3 = \frac{-2}{1.70}(+0.28+0.29) = \frac{-2}{1.70}(+0.57) = -0.67$

$V4 = \frac{-2}{3.40}(-0.43-1.13-0.50-1.28) = \frac{-2}{3.40}(-3.34) = +1.97$

$V5 = \frac{-2}{3.40}(+1.69+4.45+2.93+6.95) = \frac{-2}{3.40}(+16.02) = -9.40$

3 *Δ's.*

$+34.60\Delta 5 - 303\Delta 4 + 975\Delta 3 = (55.70-0.67)10^4 = 55.03\times 10^4$

$-103\Delta 5 + 485\Delta 4 - 302\Delta 3 = (53.30+1.97)10^4 = 55.27\times 10^4$

$+280\Delta 5 - 102\Delta 4 + 34.30\Delta 3 = (50.70-9.40)10^4 = 41.30\times 10^4$

$\Delta 3 = 0.122$

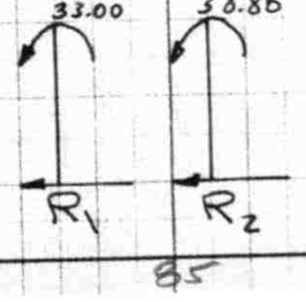
$\Delta 4 = 0.236$

$\Delta 5 = 0.218$

JOINT	2			3			4		4a			3a				2a			
MEMBER	I	R	S	I	R	S	I	R	L	R	I	S	L	R	I	S	L	R	I
DIST. FACTOR	0.41	0.20	0.39	0.40	0.20	0.40	0.66	0.34	0.25	0.25	0.50	0.33	0.17	0.17	0.33	0.33	0.17	0.17	0.34
Influence of Δ 4					+31.50	-370 +122	-370 +244	+126	+63		-370 +61	-370 +122	+63	+63	+122	+6			
			+43.30	+86.50	+43.50	+86.50	+43.30	+31	+62	+61	+123	+61.50	+21.30						
	-17.70	-8.60	-17.00	-8.60	-7.10	-24.70	-49.40	-29.90	-12.50		-13.80	-27.50	-14.20	-14.10	-27.50	-13.80	-4.30		
		-3.70	+8.40	+16.10	+8.00	+16.20	+8.20	+3.20	+6.40	+6.40	+13.50	+6.80	+4.00		-7.10	-14.10	-7.40	-6.90	-14.50
	-1.80	-0.90	-1.70	-0.90	-0.30	-3.80	-7.50	-3.80	-1.90		-0.70	-1.30	-0.50	-0.60	-1.30	-0.70	-0.50		
			+1.00	+2	+1	+2	+1.00	+0.40	+0.70	+0.60	+1.30	+0.70	+0.50		+0.20	+0.40	+0.20	+0.20	+0.40
		+0.10			-0.20	-0.40	-0.80	-0.60	-0.30		-0.20	-0.40	-0.30	-0.30	-0.40	-0.20			
	-0.50	-0.20	-0.40	-0.20				0	+0.10	+0.10	+0.30	+0.20				+0.20	-0.10		+0.10
	-20.00	-13.30	+33.30	+0.30	+0.20	+0.30	+0.20 -0.20		+117.50	+68.10	-185.60	-0.20	+0.10		-0.10	+32.80	-12.10	-6.70	-14.00
				+95.30	+76.60	-171.90	-131.30	+131.30				-208.20	+74.40	+48	+85.80				
Influence of Δ 3		+31.50	-370	-370											-3.70 +61	-370 +122	+63	+59	+126
			+74	+148	+74	+148	+74												
	+108	+52.50	+104	+52	+23						+45	+90	+37 +46	+46	+90	+45	+26.80		
		-6.00	-15	-30	-15	-30	-15						-7.50		-11.80	-23.60	-12.10	-11.40	-24.20
	+8.60	+4.20	+8.20	+4.10		-19.50	-39	-20	-10								+2.10		
								-4.40	-8.80	-8.70	-17.50	-8.80							
					+2.40						+4.60	+9.20	+4.80	+4.80	+9.30	+4.60			
		-0.60	+2.60	+5.20	+2.60	+5.20	+2.60	-0.60	-1.20	-1.10	-2.30	-1.20	+1.30		-1.10	-2.20	-1.10	-1.10	-2.30
	-0.80	-0.40	-0.80	-0.40 -0.20	0	+0.80 -0.20	+1.60	+0.80	+0.40 -0.10	-0.10	+0.20 -0.40	+0.30	+0.20	+0.20	+0.30	-1.0 20 0	-0.20 0	0	0
	+115.80	+81.20	-197.00	-191.40	+87	+104.40	+24.20	-24.20	-19.70	-9.90	+29.60	+89.50	+81.80	+51.00	-222.30	-224	+78	+46.50	+119.50
Influence of Δ 3	-358	+30.50													+59	+118	+61	+57	-358 +122
	+134	+65.50	+128	+64													+32.80		
			-12.80	-25.60	-12.80 -4.50	-25.60	-12.80				-8.70	-17.30	-6.40 -9	-9	-17.30	-8.70			
						+4.20	+8.40	+4.40	+2.10						-4	-7.90	-4.10	-3.90	-8.20
	+6.10	-2.10 +3.00	+5.80	+2.90				+0.80	+1.60	+1.70	+3.30	+1.70					+1.50		
			-0.50	-1.00	-0.60 +0.20	-1.00	-0.50				+0.40	+0.80	-0.30 +0.40	+0.40	+0.80	+0.40			
		-0.20				+0.10	-0.20	-0.10	+0.10						-0.30	-0.60	-0.30	-0.30	-0.70
	+0.30	+0.10	+0.30	+0.10					-0.10	-0.10	-0.30	-0.10				+101.20	+90.90	+52.80	-244.90
							-5.10	+5.10				+0.10	+0.10	+0.10	+0.10				
				-0.20	-0.10	-0.20			+3.70	+1.60	-5.30								
	-217.60	+96.80	+120.80	+40.20	-17.80	-22.40						-14.80	-15.20	-8.50	+38.50				
Influence of Moment of Above Floor								-12.25		-19.00									
								+2.38	+4.75	+4.75	+9.50	+4.75							
					-0.40	+3.26	+6.52	+3.35	+1.68		-0.79	-1.57	-0.80	-0.81	-1.57	-0.79			
															+0.13	+0.26	+0.13	+0.13	+0.27
		+0.07	-0.57	-1.14	-0.58	-1.14	-0.57	-0.11	-0.22	-0.22	-0.45	-0.23	-0.29						
												+0.13	+0.06	+0.07	+0.13	+0.07			
							+0.45	+0.23	+0.12		+0.07						+0.05		
	+0.20	+0.10	+0.20	+0.10	+0.03	+0.23						-0.05			-0.02	-0.04	-0.02	-0.02	-0.04
								-0.03	-0.05	-0.05	-0.09								
		-0.01	-0.07	-0.14	-0.08	-0.14	-0.07						-0.04						
							+0.07	+0.03	+6.28	+4.48	+8.24	+0.04	+0.02	+0.01	+0.04				
	+0.03	+0.02	+0.03	-1.18	-1.03	+2.21										-0.50	+0.16	+0.11	+0.23
	+0.23	+0.18	-0.41				+6.40	+5.85				+3.07	-1.05	-0.73	-1.24				
Final Moments	-3.50 +31.00 -60.50					-29.80 +27.80 -6.20	-22.70 +6.45 -1.42	+22.70 -6.45 +1.42	+20.40 -5.35 +1.03	+11.80 -2.65 +0.45	-32.20 +7.90 -1.48	-3.61 +23.80 -4.10							-2.50 +31.70 -68.00
	33.00					-8.20	-17.67	+17.67	+16.18	+9.60	-25.78	-16.40							-38.80

Checking Results

$$R_1 + R_2 = \frac{33 + 38.80}{2.45} = \frac{71.80}{2.45} = 29.20$$



$\Sigma Fx = 58.40 - 2 \times 29.20 = 0$ T.

O.K

ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER : RIAD SHAHIN		WIND ANALYSIS
CHK'D BY : RIAD SHAHIN		HARDY CROSS METHOD
APP'D BY : Dr JACK NASSER	DATE : DECEMBER 1984	SHEET No 85

85

4 - 3 - 2 Floors

1. *Shears*

$V_2 = \frac{-2}{2.45}(-20.00-14.00) = \frac{-2}{2.45}(-34.00) = +27.70 = +27.70\Delta_4/10^4$

$V_3 = \frac{-2}{3.40}(+33.30+95.30+32.80+85.80) = \frac{-2}{3.40}(+247.20) = -145 = -145\Delta_4/10^4$

$V_4 = \frac{-2}{3.40}(-171.90-131.30-208.20-185.60) = \frac{-2}{3.40}(-697.00) = +410 = +410\Delta_4/10^4$

$V_2 = \frac{-2}{2.45}(+115.80+119.50) = \frac{-2}{2.45}(+235.30) = -192 = -192\Delta_3/10^4$

$V_3 = \frac{-2}{3.40}(-197.00-191.40-224-222.30) = \frac{-2}{3.40}(-834.70) = +490 = +490\Delta_3/10^4$

$V_4 = \frac{-2}{3.40}(+104.40+24.20+89.50+29.60) = \frac{-2}{3.40}(+247.70) = -146 = -146\Delta_3/10^4$

$V_2 = \frac{-2}{2.45}(-217.60-244.90) = \frac{-2}{2.45}(-462.50) = +377 = +377\Delta_2/10^4$

$V_3 = \frac{-2}{3.40}(+120.80+40.20+38.50) = \frac{-2}{3.40}(+300.70) = -177 = -177\Delta_2/10^4$

$V_4 = \frac{-2}{3.40}(-22.40-5.10-14.80-5.30) = \frac{-2}{3.40}(+47.60) = +28 = +28\Delta_2/10^4$

2. *Effect of 5th floor.*

$V_2 = \frac{-2}{2.45}(+0.23+0.23) = \frac{-2}{2.45}(+0.46) = -0.38$

$V_3 = \frac{-2}{3.40}(-0.41-1.18-0.50-1.29) = \frac{-2}{3.40}(-3.38) = +2.00$

$V_4 = \frac{-2}{3.40}(+2.21+6.40+3.07+8.24) = \frac{-2}{3.40}(+19.92) = -12.70$

3. *Δ's*

$+27.70\Delta_4 - 192\Delta_3 + 377\Delta_2 = (58.40-0.38)10^4 = 58.02\times10^4$

$-145\Delta_4 + 490\Delta_3 - 177\Delta_2 = (55.70+2.00)10^4 = 57.70\times10^4$

$+410\Delta_4 - 146\Delta_3 + 28\Delta_2 = (53.30-12.70)10^4 = 40.60\times10^4$

$\Delta_2 = 0.277$

$\Delta_3 = 0.267$

$\Delta_4 = 0.174$

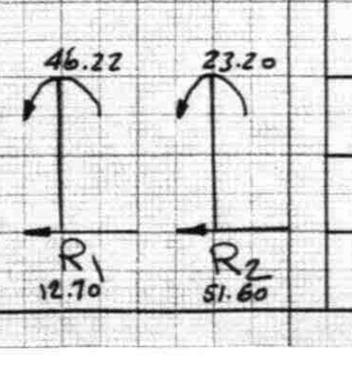
JOINT	0	1			2			3		3a			2a				1a				0a
MEMBER	S	I	R	S	I	R	S	I	R	L	R	I	S	L	R	I	S	L	R	I	S
DIST. FACTOR	0	0.48	0.22	0.30	0.32	0.23	0.45	0.66	0.34	0.25	0.25	0.50	0.37	0.19	0.18	0.26	0.25	0.18	0.17	0.40	0
Influence of Δ3							-370	-370				-370	-370								
						+35	+122	+244	+126	+63		+68.50	+137	+70	+67	+96	+48				
				+34	+68	+49	+96	+48	+30	+60	+59.50	+119	+59.50	+24.50							
						-8	-25.50	-51	-27	-13.50		-15.50	-31	-16	-15	-22	-11				
			-3.30						+4.80	+4.80	+4.70	+9.50	+4.80			-4.60	-9.20	-6.60	-6.40	-14.80	-7.40
	-7.40	-14.80	-6.70	-9.20	-4.60													-3.40			
				+6.10	+12.20	+8.80	+17.10	+8.60						+4.40							
												-0.90	-1.70	-0.90	-0.80	-1.20	-0.60				
	-1.50	-2.90	-1.40	-1.80	-0.90	-0.50	-4.40	-8.80	-4.60	-2.30								-0.70			
			+0.40						+0.40	+0.80	+0.80	+1.60	+0.80			+0.60	+1.20	+0.80	+0.80	+1.90	+1
				+1.00	+1.90	+1.30	+2.60	+1.30						+0.70							
	-0.40	-0.70	-0.30	-0.40	-0.20	-0.20	-0.60	-1.10	-0.60	-0.30		-0.40	-0.80	-0.40	-0.40	-0.50	-0.30	-0.20			
																0	+0.10	+0.10	+0.10	+0.20	+0.10
	-9.30	-18.40	-11.30	+29.70	+0.30	+0.20	+0.50	+0.30	0	+0.10	+0.20	+0.40	+0.20	+0.10							
								-0.20	-0.10				-0.10	-0.10		-0.10	+28.20	-10.00	-5.50	-12.70	-6.50
					+76.70	+85.60	-162.30			+112.60	+65.20	-175.80	-201.30	+82.50	+50.80	+68.20					
								-128.90	+128.90												
Influence of Δ2				-179	-179											-179	-179				
			+16	+28.50	+57	+41	+81	+40.50						+20.50		+22.50	+45	+32	+30	+72	+36
	+32.30	+64.50	+29.50	+40.50	+20.30	+13	-13.30	-26.50	-14	-7		+25	+50	+26	+25	+35	+17.50				
																		+14.80			
				-3.20	-6.40	-4.60	-9.00	-4.50	-2.30	-4.50	-4.50	-9	-4.50	-2.30							
			-2.90													-4.10	-8.10	-5.80	-5.50	-12.90	-6.50
	+1.50	+2.90	+1.30	+1.90	+1.00	+1.10	+2.30	+4.50	+2.30	+1.20											
												+2	+4	+2.10	+2	+2.80	+1.40	+0.70			
				-0.70	-1.40	-1.00	-2	-1													
			-0.20						-0.46	-0.80	-0.80	-1.60	-0.80	-0.50		-0.30	-0.50	-0.46	-0.40	-0.80	-0.40
	+0.20	+0.40	+0.20	+0.30	+0.20																
						+0.20	+8.40	+0.80	+0.60	+0.30		+0.30	+0.60	+0.30	+0.30	+0.40	+0.20	+0.10			
	+34.00	+67.80	+43.90	-111.70																	+29.10
					-0.20	-0.20	-0.40	-0.20	-0.10	-0.10	-0.20	-0.40	+49.30	+46.10	+27.30	-122.70	-0.10			-0.20	
								+0.20	+0.10												
					-108.50	+49.50	+59			-10.05	-5.40	+16.30								+58.12	
								+13.20	-13.80								-23.60	+41.40	+24.10		
Influence of Δ1	-213	-213																		-213	-213
			+19																		
	+46.50	+93	+43	+58	+29											+26.50	+53	+38	+37	+85	+42.50
				-4.70	-9.30	-6.70	-13	-6.50										+21.50			
														-3.40							
						-2.20	+2.20	+4.30	+2.20	+1.10		-4.30	-8.50	-4.40	-4.20	-6	-3				
			-1.70																		
	+1.60	+3.10	+1.40	+1.90	+1.00				+0.40	+0.80	+0.80	+1.60	+0.80			-2.30	-4.60	-3.30	-3.20	-7.40	-3.70
	-164.90	-116.90	+61.70	+55.20		-0.20						+0.30	+0.60	+0.30	+0.20	+0.40	+0.20	+0.70			
					-0.20	-0.20	-0.40	-0.20													
								-0.10	-0.10	-0.10	-0.10	-0.10	-7.10	-7.50	-4.00	+18.60	-0.20	-0.10	-0.10	-0.50	0
					+20.50	-9.30	-11.20														
								-2.50	+2.50	+1.80	+0.70	-2.50					+45.40	+56.80	+33.70	-135.90	-142.20
Influence of Moment of Above Floor								-8.20			-16.40										
									+2.05	+4.10	+4.10	+8.20	+4.10								
						-0.39	+2.03	+4.05	+2.10	+1.05		-0.75	-1.50	-0.78	-0.74	-1.08	-0.54				
			+0.05	-0.26	-0.52	-0.38	-0.74	-0.37	-0.04	-0.08	-0.07	-0.15	-0.08	-0.19		+0.07	+0.14	+0.10	+0.09	+0.21	+0.11
	+0.05	+0.10	+0.05	+0.06	+0.03		+0.14	+0.27	+0.14	+0.07		+0.04	+0.07	+0.04	+0.04	+0.05	+0.03	+0.03			
						+0.02															
				-0.03	-0.06	-0.04	-0.09	-0.05	-0.02	-0.03	-0.03	-0.05	-0.03	-0.02		-0.01	-0.02	-0.01	-0.01	-0.02	-0.01
	0	+0.01	+0.01	+0.0									+0.02	+0.01	+0.01	+0.02	-0.39	+0.12	+0.08	+0.19	+0.10
					-0.55	-0.79	+1.34	+0.04	+0.03	+5.11	+4.50	+7.29									
	+0.05	+0.11	+0.11	-0.22				+3.94	+4.26				+2.58	-0.94	-0.69	-0.95					
Final Moments	-2.02	-4.00	-2.45	+6.45	+16.60	+18.50	-35.10	-28	+28	+29.50	+14.00	-38.50	-43.70	+17.90	+11.00	+14.80	+6.12	-2.17	-1.20	-2.75	-1.41
	+17.80	+35.50	+23	-58.50	-57.00	+26.00	+31.00	+6.75	-6.75	-5.75	-2.75	+8.50	+26.00	+24.20	+14.30	-64.50	-65.00	+21.70	+12.70	+30.60	+15.30
	-62.00	-44.20	+23.25	+21.00	+7.70	-3.50	-4.20	-0.95	+0.95	+0.68	+0.26	-0.90	-2.67	-2.83	-1.50	+7.00	+17.15	+21.00	+12.90	-51.05	-65.50
	-46.22	-12.70	+43.75	-31.05	-32.70	+41	-8.30	-22.20	+22.20	+19.43	+11.51	-30.94	-20.37	+39.27	+23.80	-42.70	-41.78	+40.53	+24.40	-23.20	-51.60

Checking Results:

$R_1 + R_2 = \frac{46.22 + 12.70 + 23.20 + 51.60}{4.50} = \frac{33.72}{4.50} = 30T.$

$\Sigma Fx = 60 - 30 \times 2 = 0T$

∴ O.K.



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER : RIAD SHAHIN		WIND ANALYSIS
CHK'D BY : RIAD SHAHIN		HARDY CROSS METHOD
APP'D BY : Dr. JACK NASSER	DATE : DECEMBER 1964	SHEET No 87 /

87

3 - 2 - 1 Floors

1. Shears

$$V_1 = \frac{-2}{4.50}(-9.30-18.40-6.50-12.70) = \frac{-2}{4.50}(-46.90) = +20.80 = +20.80\,\Delta_3/10^4$$

$$V_2 = \frac{-2}{4.90}(+29.70+76.70+28.20+68.20) = \frac{-2}{4.90}(+202.80) = -83 = -83\,\Delta_3/10^4$$

$$V_3 = \frac{-2}{3.40}(-162.30-128.90-201.30-175.80) = \frac{-2}{3.40}(-668.30) = +391 = 391\,\Delta_3/10^4$$

$$V_1 = \frac{-2}{4.50}(+34.00+67.80+29.10+58.10) = \frac{-2}{4.50}(+189.00) = -84 = -84\,\Delta_2/10^4$$

$$V_2 = \frac{-2}{4.90}(-111.70-108.50-123.60-122.70) = \frac{-2}{4.90}(-466.50) = +190 = +190\,\Delta_2/10^4$$

$$V_3 = \frac{-2}{3.40}(+59.00+13.80+49.30+16.30) = \frac{-2}{3.40}(+138.40) = -81.20 = -81.20\,\Delta_2/10^4$$

$$V_1 = \frac{-2}{4.50}(-164.90-116.90-174.20-135.90) = \frac{-2}{4.50}(-591.90) = +263 = +263\,\Delta_1/10^4$$

$$V_2 = \frac{-2}{4.90}(+55.20+20.50+45.50+18.60) = \frac{-2}{4.90}(+139.80) = -57 = -57\,\Delta_1/10^4$$

$$V_3 = \frac{-2}{3.40}(-11.20-2.50-7.10-2.50) = \frac{-2}{3.40}(-23.30) = +13.70 = 13.70\,\Delta_1/10^4$$

2. Effect of 4th floor

$$V_1 = \frac{-2}{4.50}(+0.05+0.11+0.10+0.19) = \frac{-2}{4.50}(+0.45) = -0.20$$

$$V_2 = \frac{-2}{4.90}(-0.22-0.55-0.39-0.95) = \frac{-2}{4.90}(-2.11) = +0.86$$

$$V_3 = \frac{-2}{3.40}(+1.34+3.94+2.58+7.29) = \frac{-2}{3.40}(+15.15) = -8.90$$

3. Δ's

$$+20.80\Delta_3 - 84\Delta_2 + 263\Delta_1 = (60.00-0.20)10^4 = 59.80\times10^4$$

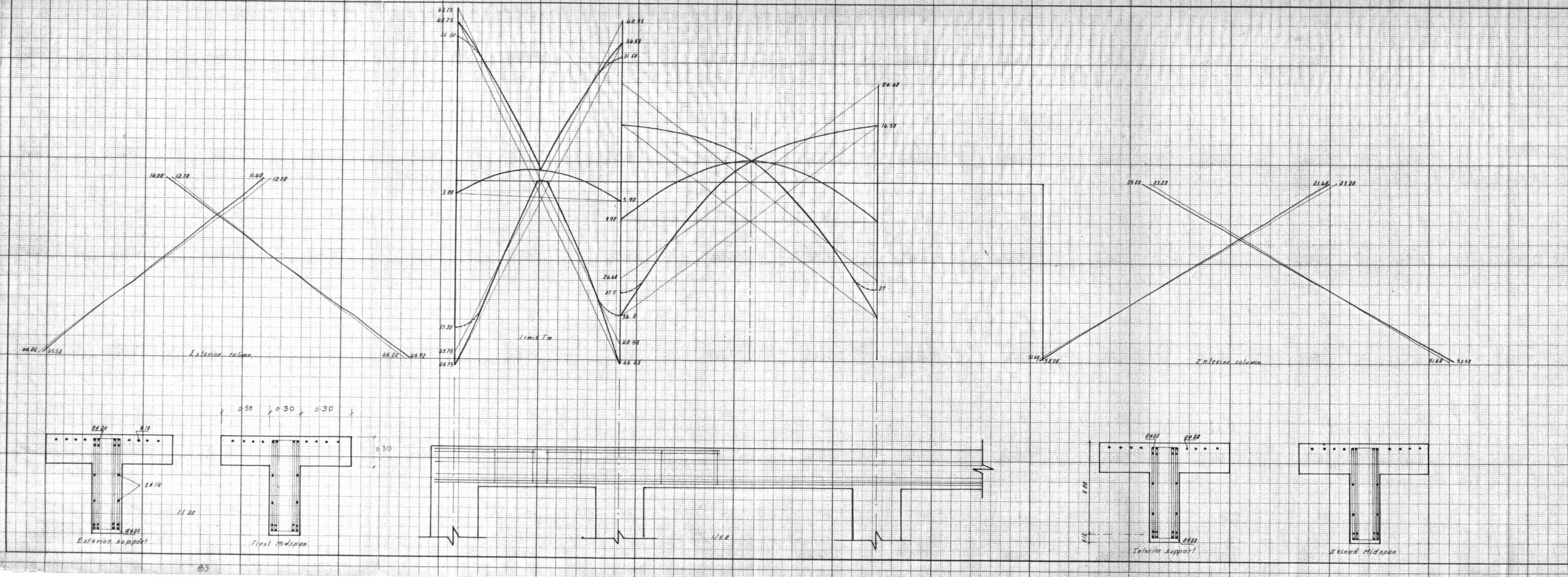
$$-83\Delta_3 + 190\Delta_2 - 57\Delta_1 = (58.40+0.86)10^4 = 59.26\times10^4$$

$$+391\Delta_3 - 81.20\Delta_2 + 13.70\Delta_1 = (55.70-8.90)10^4 = 46.80\times10^4$$

$$\Delta_1 = 0.376$$

$$\Delta_2 = 0.527$$

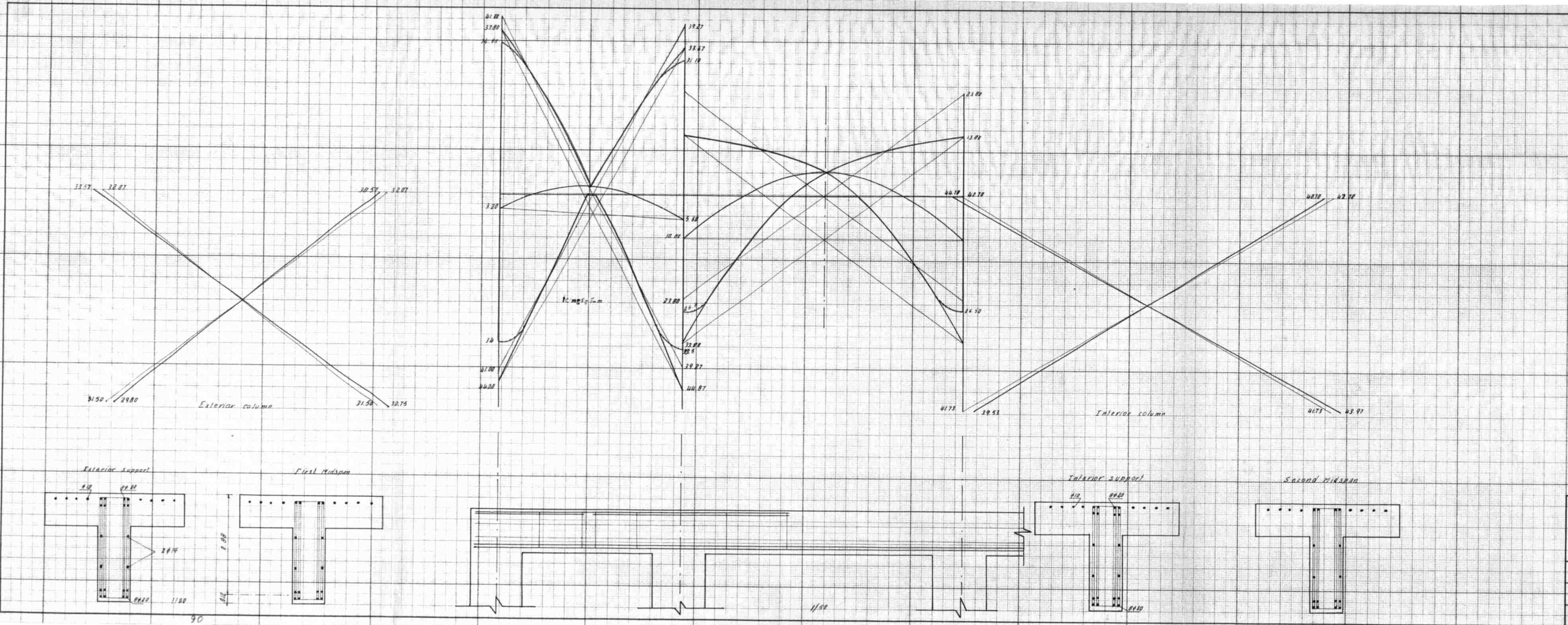
$$\Delta_3 = 0.217$$



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

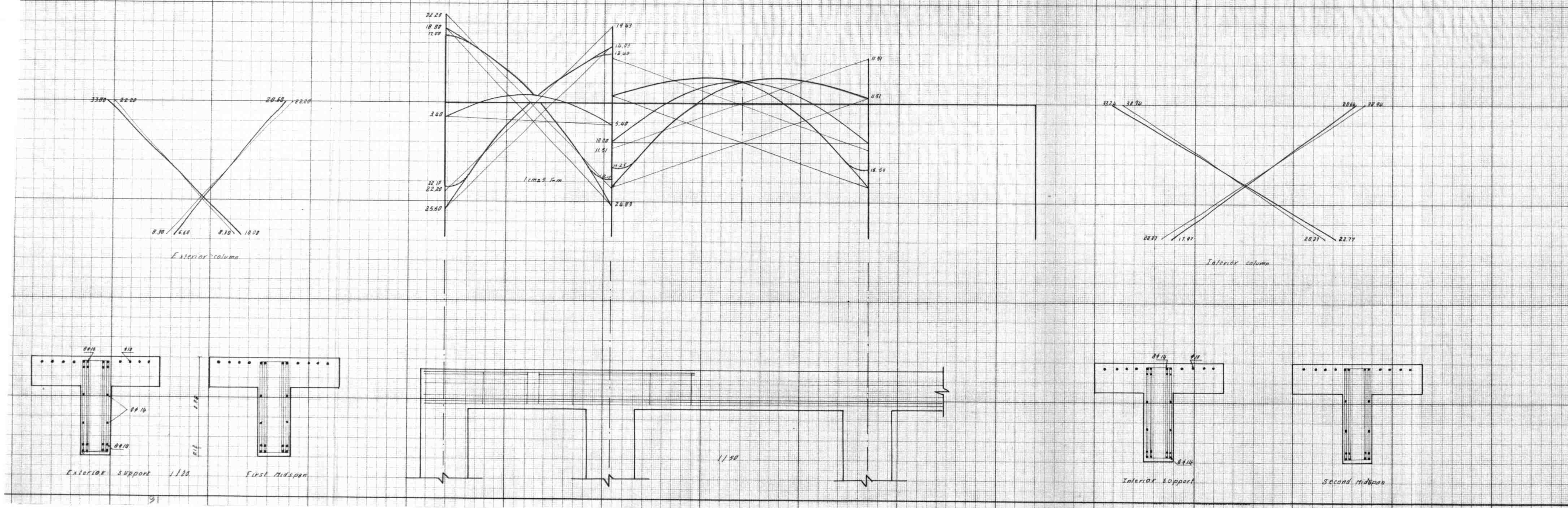
DRAWN BY :	RIAD SHAHIN	ENVELOPE DIAGRAMS
CHK'D BY :	RIAD SHAHIN	REINFORCEMENT IN BEAMS
APP'D BY :	Dr. JACK NASSER	DATE : DECEMBER 1964 — SHEET Nº 89 /



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

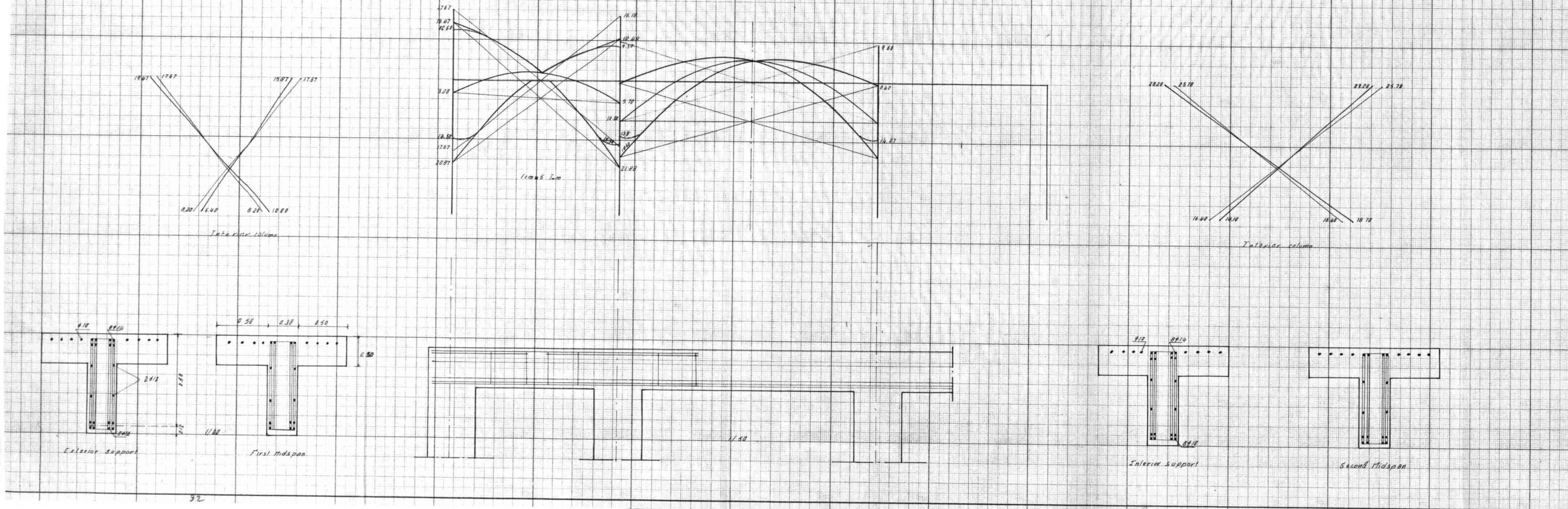
DRAWN BY : RIAD SHAHIN	ENVELOPE DIAGRAMS
CHK'D BY : RIAD SHAHIN	REINFORCEMENT IN BEAMS
APP'D BY : Dr JACK NASSER	DATE : DECEMBER 1964 — SHEET No 90



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

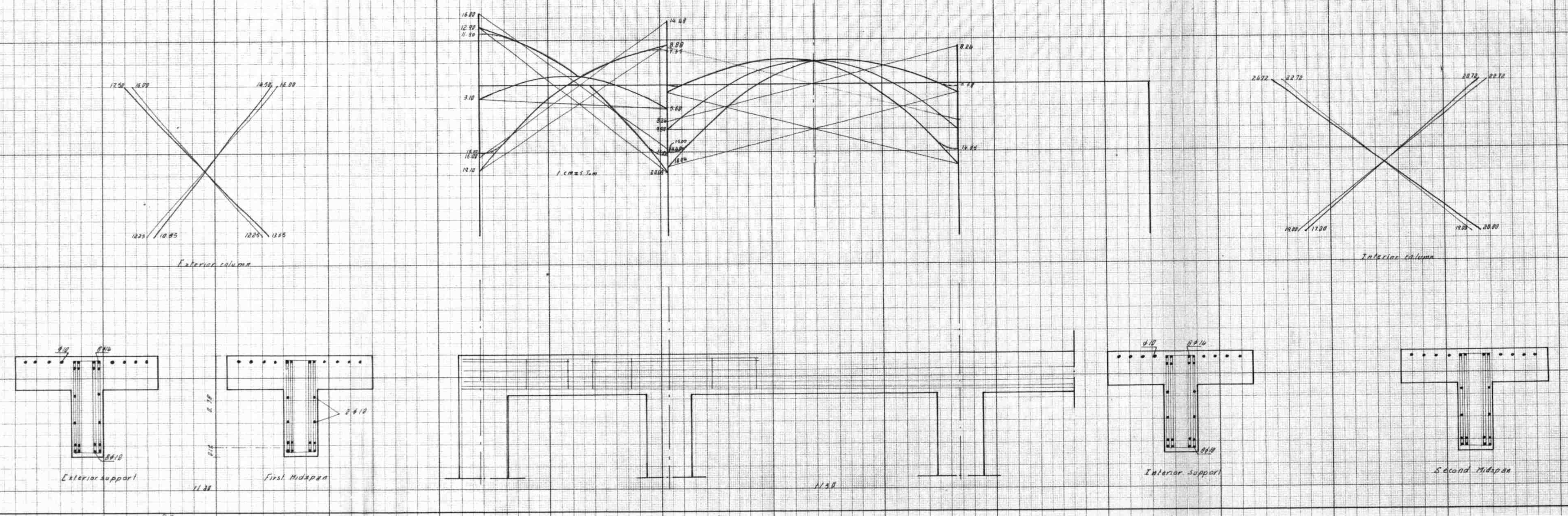
DRAWN BY : RIAD SHAHIN	ENVELOPE DIAGRAMS REINFORCEMENT IN BEAMS	
CHK'D BY : RIAD SHAHIN		
APP'D BY : Dr. JACK NASSER	DATE : DECEMBER 1964	SHEET № 91



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

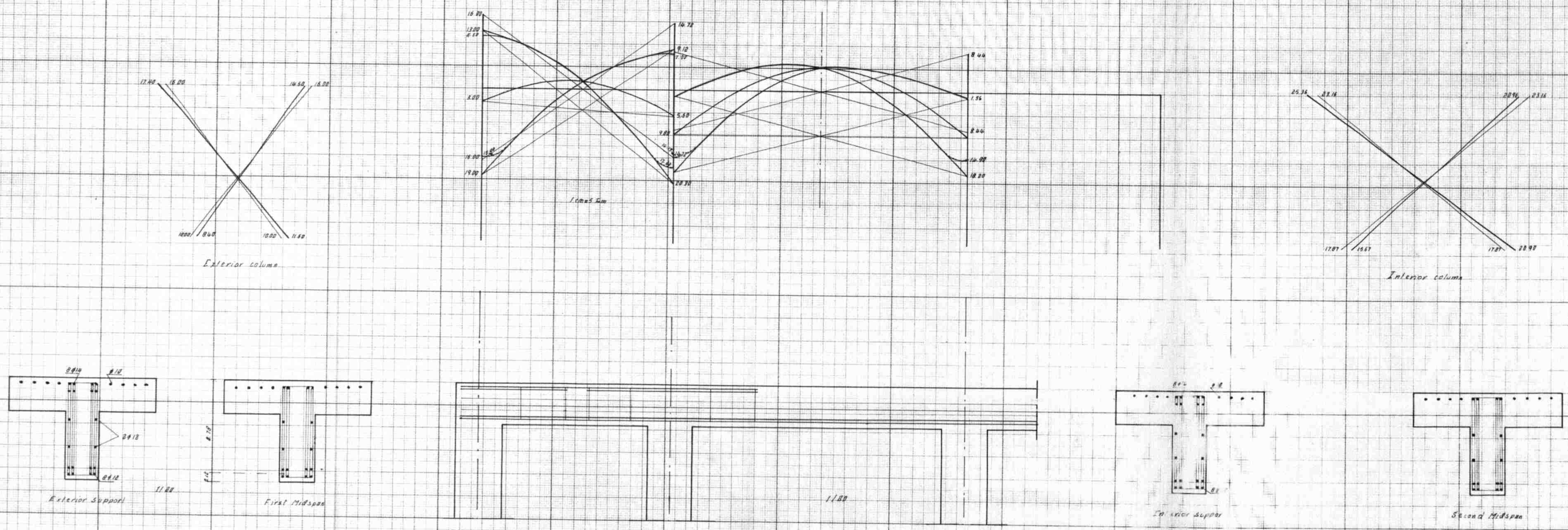
DRAWN BY : RIAD SHAHIN	ENVELOPE DIAGRAMS
CHK'D BY : RIAD SHAHIN	REINFORCEMENT IN BEAMS
APP'D BY : Dr JACK NASSER	DATE : DECEMBER 1964 — SHEET Nº 92



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

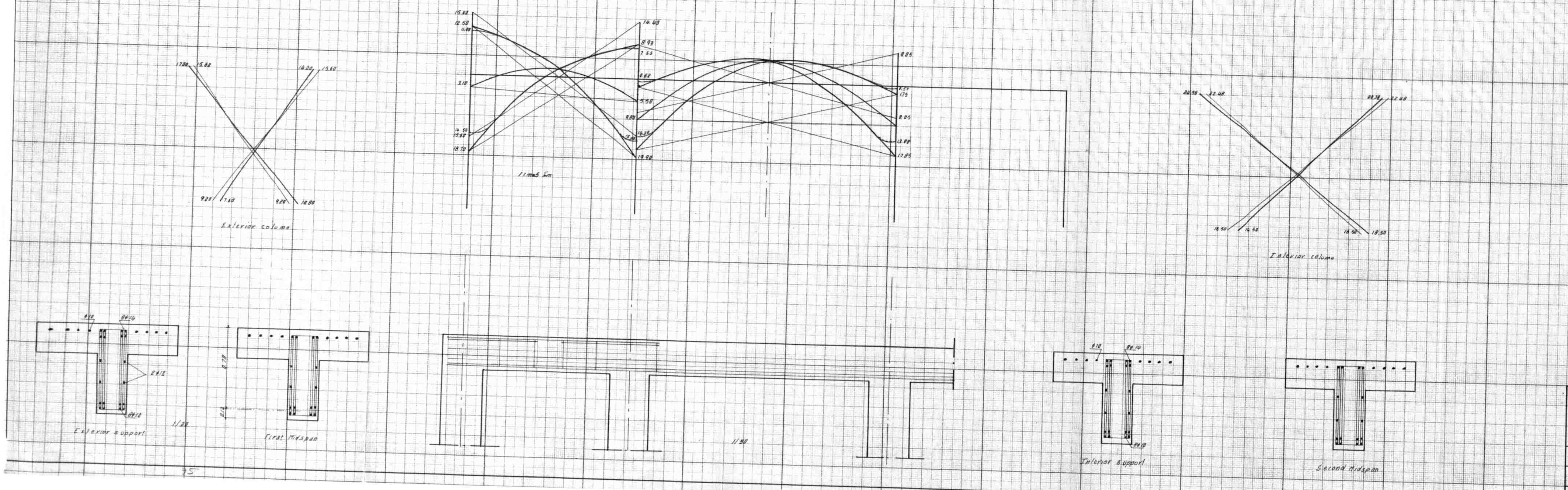
DRAWN BY :	RIAD SHAHIN	ENVELOPE DIAGRAMS REINFORCEMENT IN BEAMS	
CHK'D BY :	RIAD SHAHIN		
APP'D BY :	Dr JACK NASSER	DATE : DECEMBER 1964	SHEET No 93 /



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

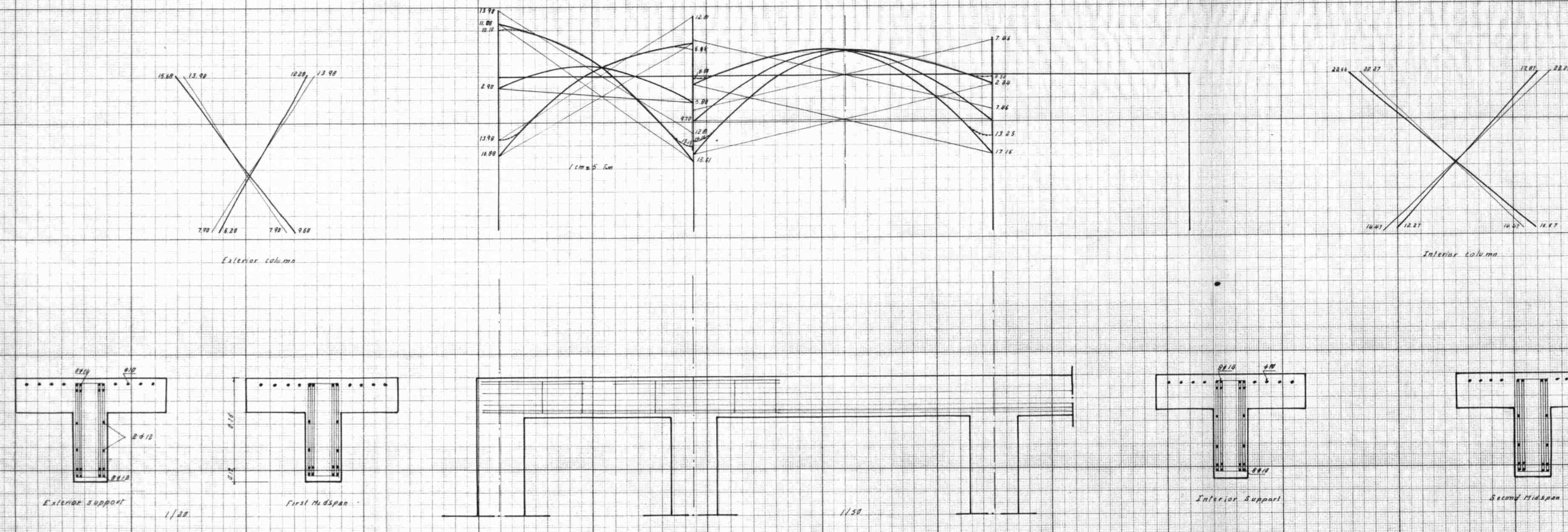
DRAWN BY : RIAD SHAHIN	ENVELOPE DIAGRAMS	
CHK'D BY : RIAD SHAHIN	REINFORCEMENT IN BEAMS	
APP'D BY : Dr. JACK NASSER	DATE : DECEMBER 1964	SHEET No. 94 /



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING.

Comparison of Approximate and Exact Methods

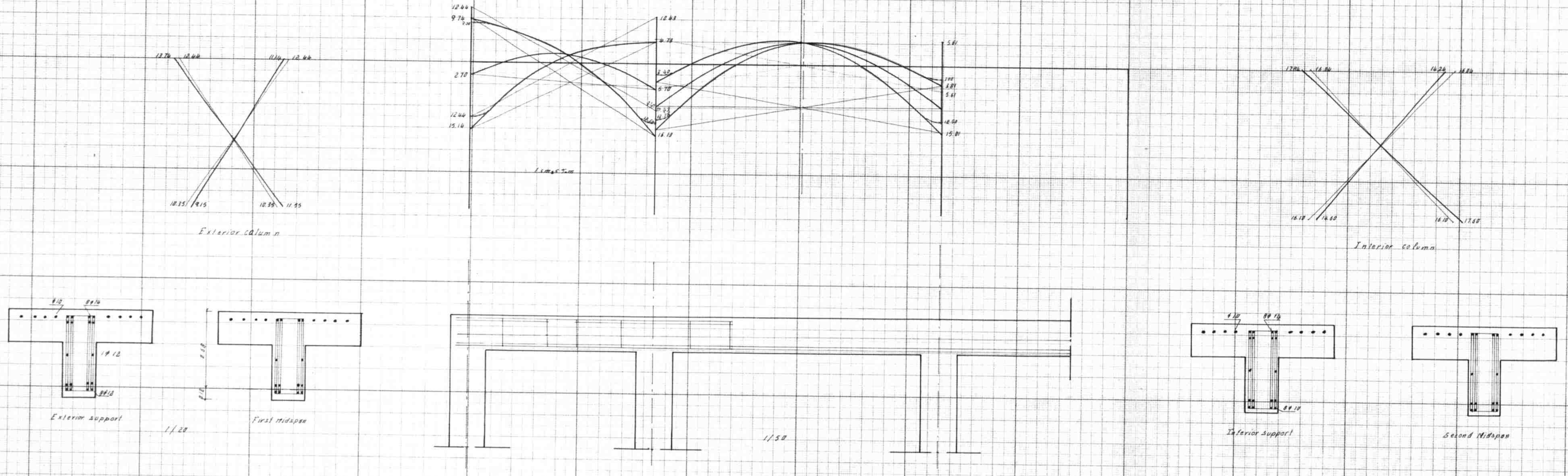
DRAWN BY : RIAD SHAHIN	ENVELOPE DIAGRAMS
CHK'D BY : RIAD SHAHIN	REINFORCEMENT IN BEAMS
APP'D BY : Dr JACK NASSER	DATE: DECEMBER 1964 — SHEET No 35



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

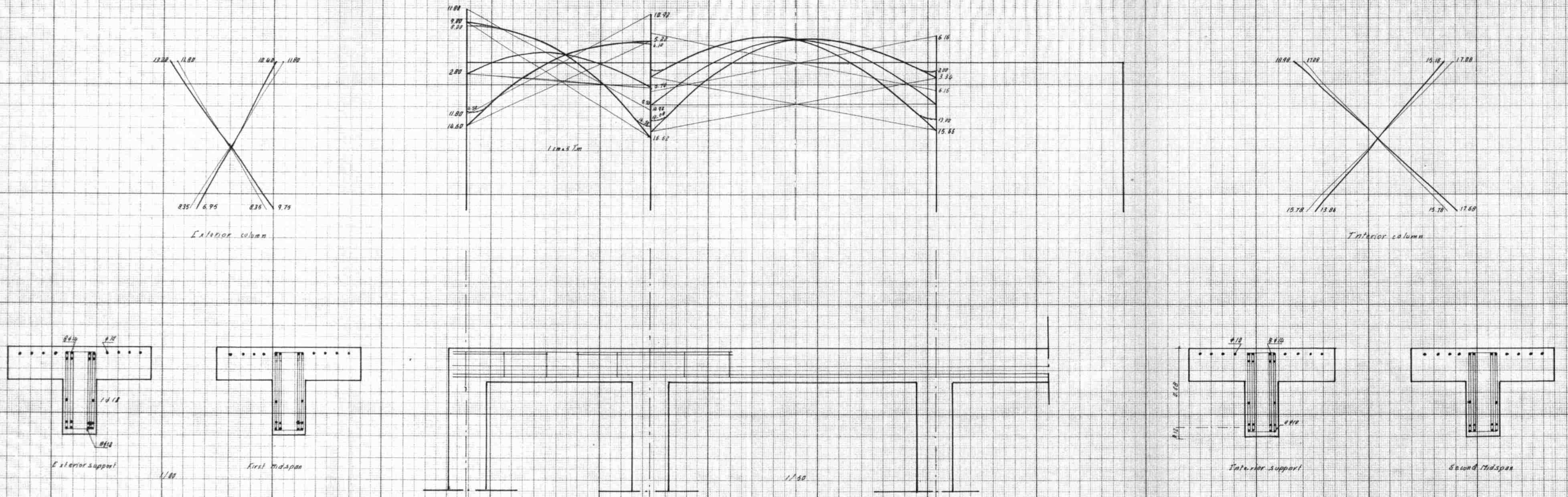
DRAWN BY : RIAD SHAHIN	ENVELOPE DIAGRAMS	
CHK'D BY : RIAD SHAHIN	REINFORCEMENT IN BEAMS	
APP'D BY : Dr JACK NASSER	DATE: DECEMBER 1964	SHEET No 96 /



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

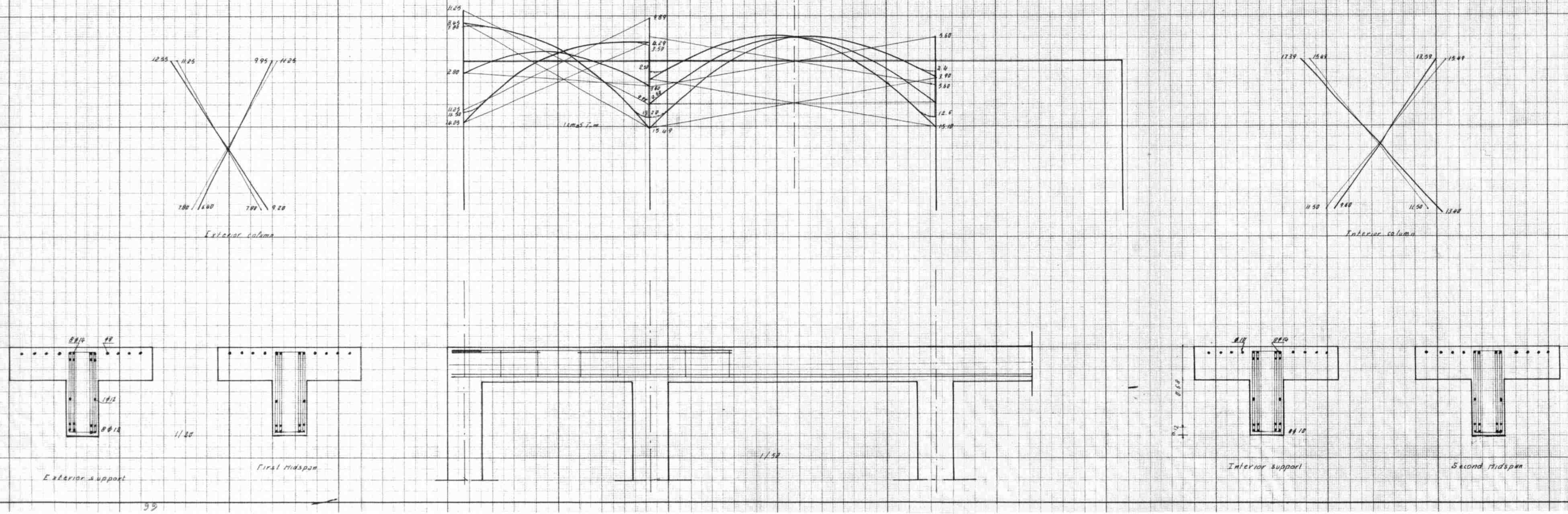
DRAWN BY :	RIAD SHAHIN	ENVELOPE DIAGRAMS REINFORCEMENT IN BEAMS
CHK'D BY :	RIAD SHAHIN	
APP'D BY :	Dr. JACK NASSER	DATE: DECEMBER 1964 — SHEET No 97



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

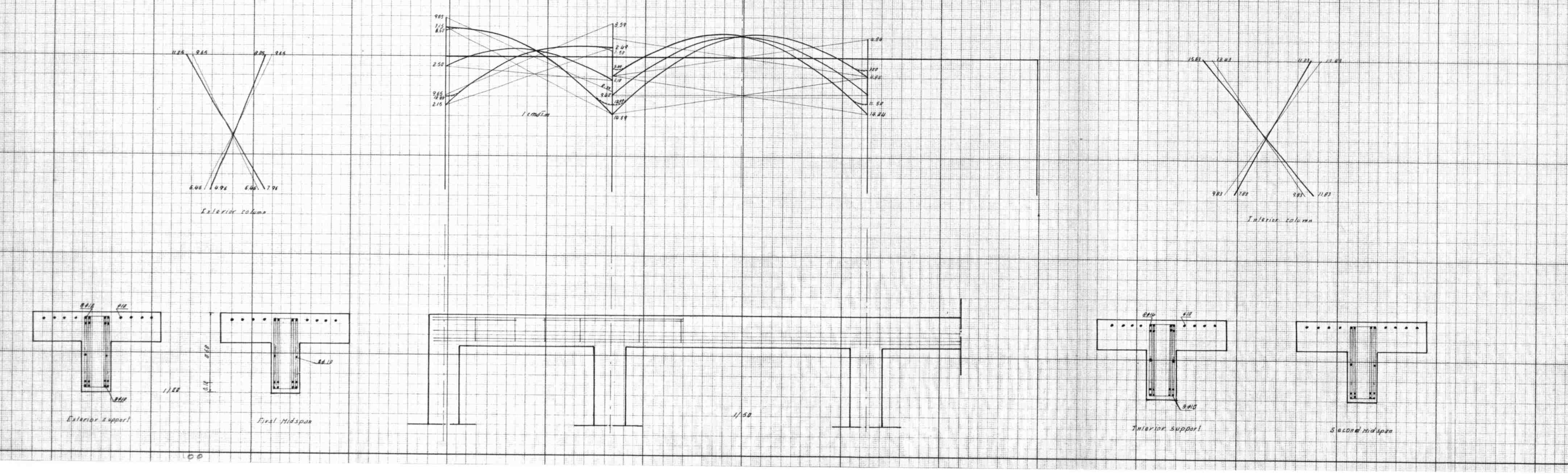
DRAWN BY : RIAD SHAHIN	ENVELOPE DIAGRAMS REINFORCEMENT IN BEAMS
CHK'D BY : RIAD SHAHIN	
APP'D BY : Dr JACK NASSER	DATE : DECEMBER 1964 — SHEET Nº 98 /



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

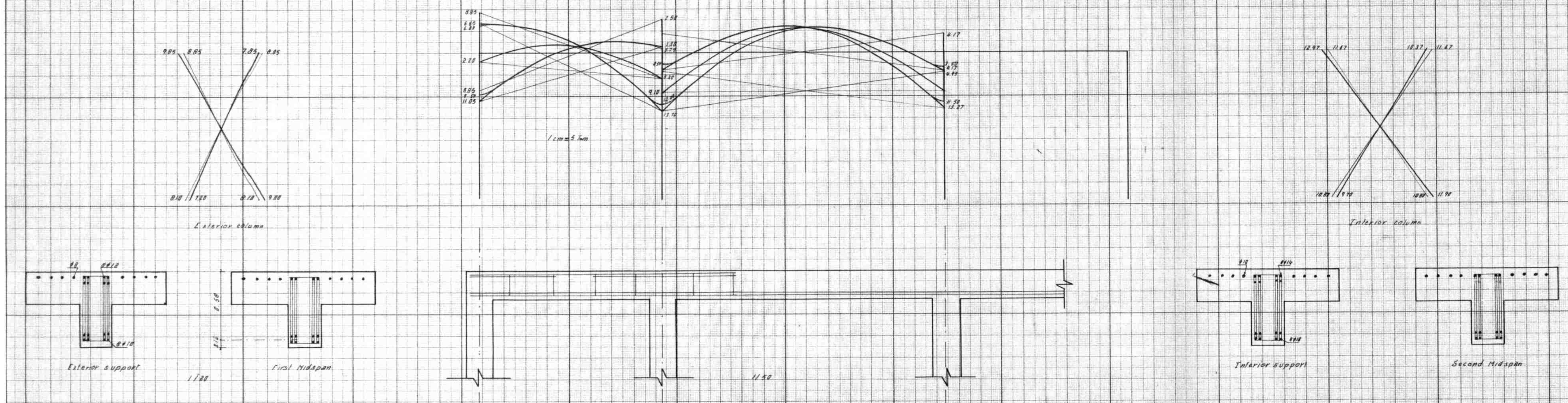
DRAWN BY :	RIAD SHAHIN	ENVELOPE DIAGRAMS
CHK'D BY :	RIAD SHAHIN	REINFORCEMENT IN BEAMS
APP'D BY :	Dr JACK NASSER	DATE : DECEMBER 1964 — SHEET No 99 /



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING.

Comparison of Approximate and Exact Methods

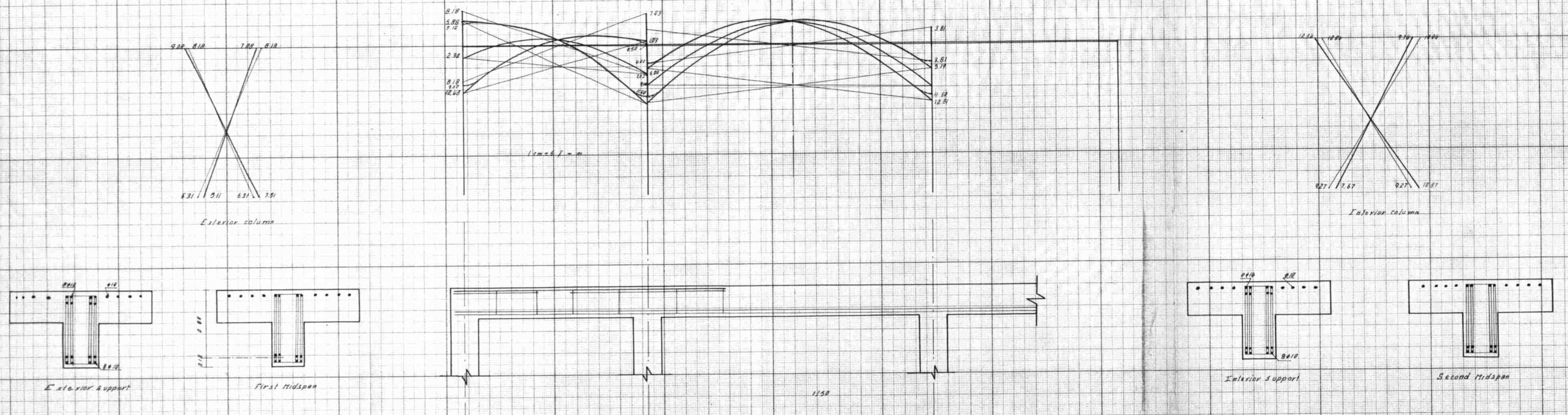
DRAWN BY :	RIAD SHAHIN	ENVELOPE DIAGRAMS
CHK'D BY :	RIAD SHAHIN	REINFORCEMENT IN BEAMS
APP'D BY :	Dr. JACK NASSER	DATE: DECEMBER 1964 — SHEET Nº 100 /



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

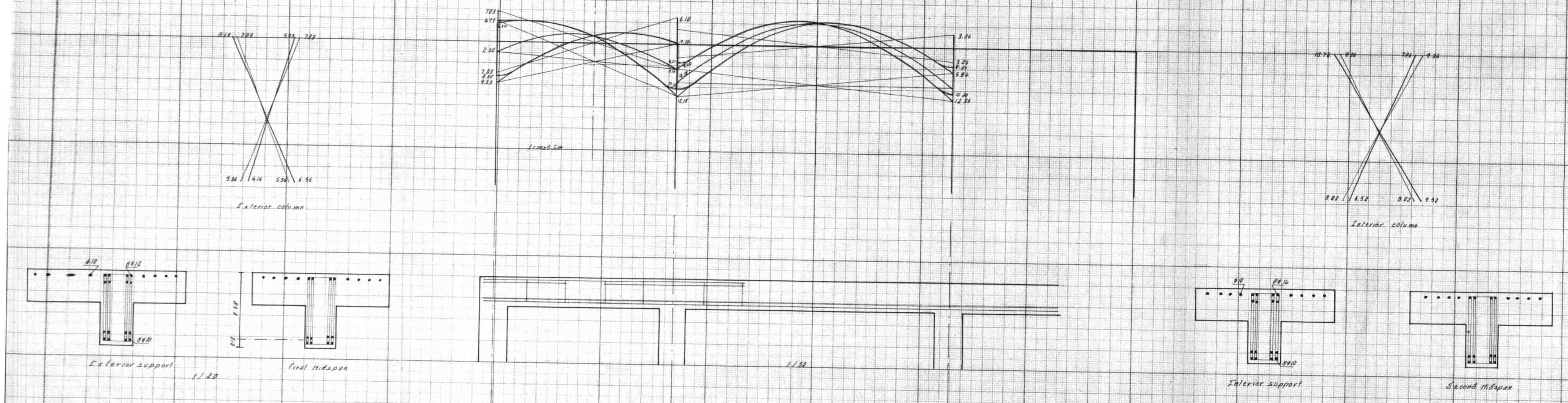
Comparison of Approximate and Exact Methods

DRAWN BY : RIAD SHAHIN	ENVELOPE DIAGRAMS	
CHK'D BY : RIAD SHAHIN	REINFORCEMENT IN BEAMS	
APP'D BY : Dr JACK NASSER	DATE : DECEMBER 1964	SHEET No 101/



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING Comparison of Approximate and Exact Methods	
DRAWN BY : RIAD SHAHIN	ENVELOPE DIAGRAMS REINFORCEMENT IN BEAMS
CHK'D BY : RIAD SHAHIN	
APP'D BY : Dr JACK NASSER	DATE : DECEMBER 1964 — SHEET Nº 102/

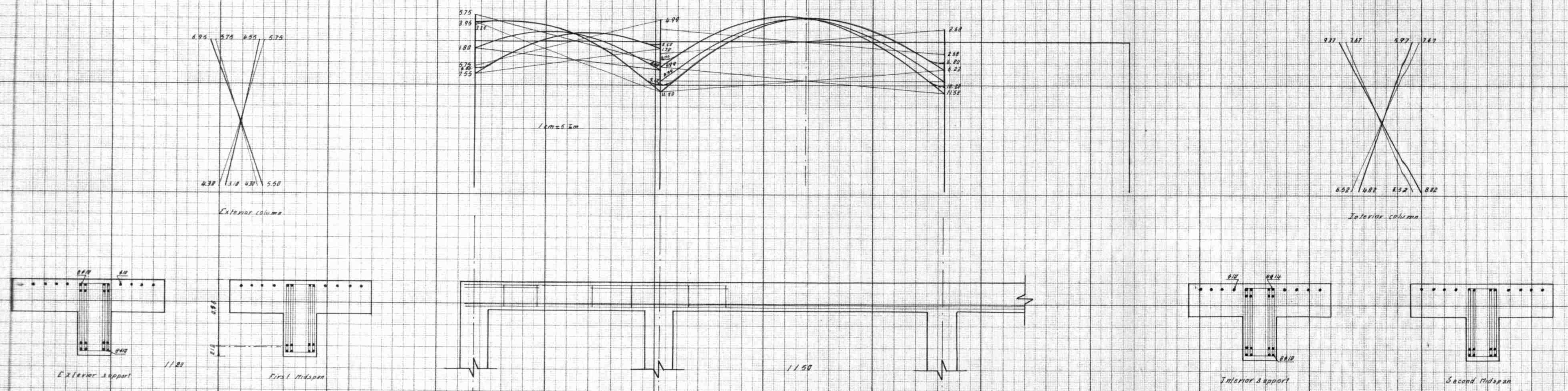
102



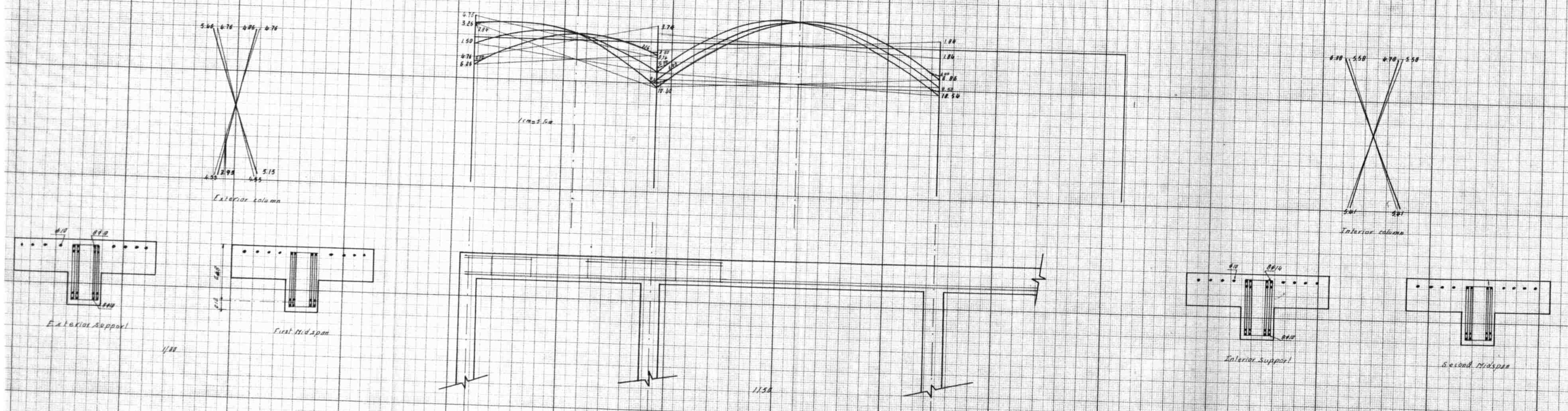
ANALYSIS OF THE EFFECT OF WIND ON A HIGH
REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

DRAWN BY : RIAD SHAHIN	ENVELOPE DIAGRAMS	
CHK'D BY : RIAD SHAHIN	REINFORCEMENT IN BEAMS	
APP'D BY : Dr. JACK NASSER	DATE : DECEMBER 1964	SHEET Nº 103 /



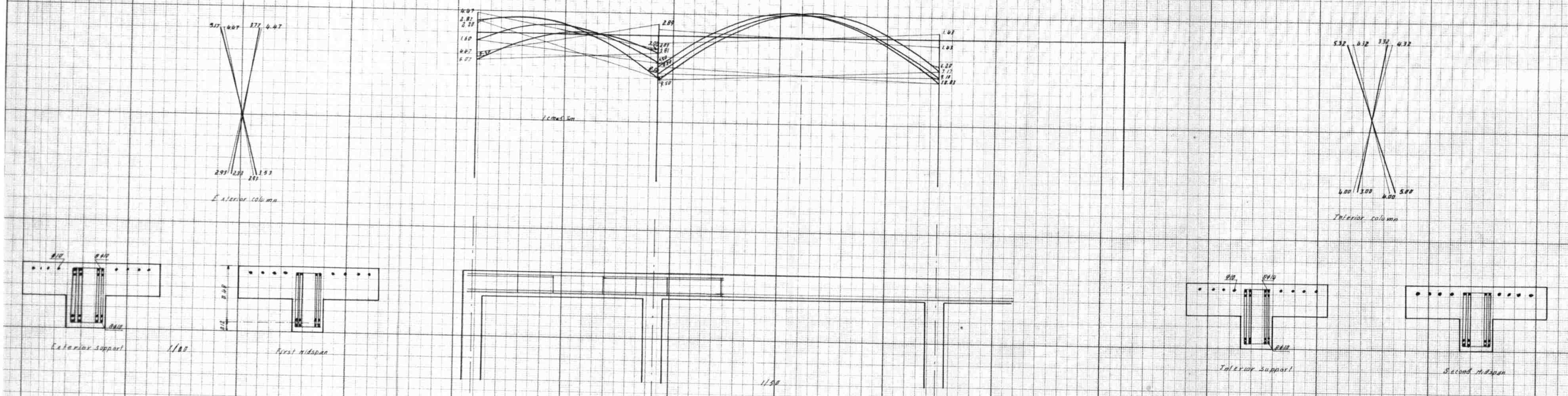
ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING	
Comparison of Approximate and Exact Methods	
DRAWN BY : RIAD SHAHIN	ENVELOPE DIAGRAMS
CHK'D BY : RIAD SHAHIN	REINFORCEMENT IN BEAMS
APP'D BY : Dr JACK NASSER	DATE : DECEMBER 1964 — SHEET No 104



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

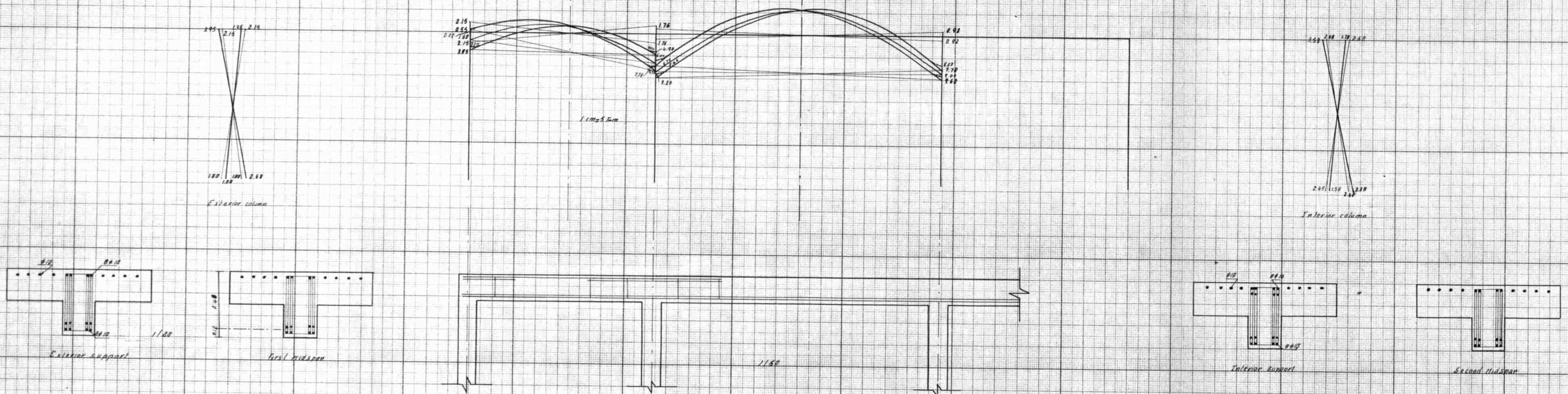
DRAWN BY : RIAD SHAHIN	ENVELOPE DIAGRAMS	
CHK'D BY : RIAD SHAHIN	REINFORCEMENT IN BEAMS	
APP'D BY : Dr. JACK NASSER	DATE : DECEMBER 1964	SHEET No 105



ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

DRAWN BY : RIAD SHAHIN	ENVELOPE DIAGRAMS
CHK'D BY : RIAD SHAHIN	REINFORCEMENT IN BEAMS
APP'D BY : Dr. JACK NASSER	DATE: DECEMBER 1964 — SHEET No 106/



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ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

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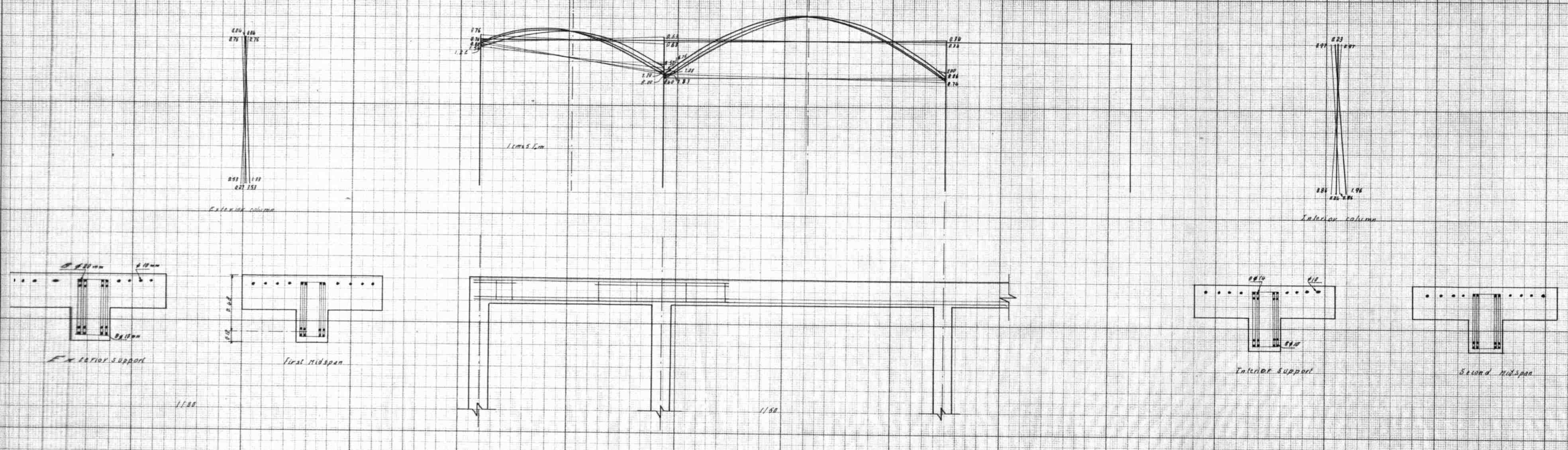
APP'D BY : Dr JACK NASSER	DATE : DECEMBER 1964 — SHEET N° 107



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CHAPTER

REINFORCED CONCRETE DESIGN

General:

Although this chapter appears as a unity, the method adopted consists in designing the slabs and long direction beams of a typical floor before making the wind analysis. The design of the slabs at an earlier stage is considered necessary because it serves as a guide with respect to the depth of the beams.

This section has no intention of being detailed.

The design of the most critical frame members was conducted for Case "C" only, whereby the structure proved to stand.

Basis of Design:

1. Working stress theory is used.

2. A.C.I. Code (1959 edition) is used. This edition was violated in designing the columns wereby 6% of steel was required for one of the members. However, the 1963 edition allows up to 8%. Furthermore, when designing the footings, reference is made to "Foundation Engineering, Peck, Hanson and Thornburn". This implies one deviation from the A.C.I. Code in the magnitude of moment and shear for flexure and bond. The A.C.I. Code recommends the use of 85 per cent of the static moment and shear for the determination of the area of the steel and for the computation of the bond stress. This procedure cannot be

justified either by statics or by experiment. With the present growing practice of using bars that develop high bond stresses without hooks, it becomes increasingly important that the full static moment and shear be used for investigating stresses at the face of the column.

3. Metric units are used.

4. A good quality concrete with a crushing strength of $f'c = 3750$ psi $= 263\ Kg/cm^2$.

5. Working stresses of concrete due to bending flexure will be $fc = 0.45 \times 263 = 118\ Kg/cm^2$.

6. Working stress of concrete due to compression will be $fc = 0.25 \times 263 = 66\ Kg/cm^2$.

7. Working stress of steel under tension is taken as:

   a. Mild steel, $fs = 20,000$ psi $= 1400\ Kg/cm^2$.

   b. High strength steel, $fs = 30,000$ psi $= 2100\ Kg/cm^2$.

8. Ratio of equivalence is $n = 8$.

9. Due to such working stresses, the resisting moment of a rectangular section under bending will be

   a. Mild Steel

   $$Mc = \frac{1}{2}\ fc.k.j.bd^2$$

   $$= \frac{1}{2} \times 1180 \times 0.405 \times 0.865\ bd^2 = 207\ bd^2\ (T\text{-}m)$$

   if b and d are in meters and f'c is in T/m^2

   b. High Strength Steel

   $$Mc = \frac{1}{2} \times 1180 \times 0.312 \times 0.896\ bd^2$$

   $$= 165\ bd^2\ (T\text{-}m)$$

   if b and d are in meters and f'c is in T/m^2.

10. Reinforcement equations will be

a. Mild Steel

$$As_1 = \frac{M_1}{fs.jd} = \frac{M_1}{14,000 \times 0.865\ d}\ m^2$$

$$= \frac{10^4\ M_1}{14,000 \times 0.865\ d}\ cm^2 = 0.825\ \frac{M_1}{d}\ cm^2$$

if M_1 is in T-m and d in meters

$$As_2 = \frac{M_2}{fs(d - d')} = \frac{M_2}{1.40(d - d')}\ cm^2$$

if M_2 is in T-m and d in meters

$$As = As_1 + As_2$$

$$A's = \frac{As_2}{2}\left(\frac{1 - k}{k - \frac{d'}{d}}\right) \frac{As_2}{2} \quad \frac{(1 - 0.405)}{(0.405 - \frac{d'}{d})}$$

$$= \frac{As_2}{2}\left(\frac{0.595}{0.405 - \frac{d'}{d}}\right)\ cm^2$$

b. High Strength Steel

$$As_1 = \frac{M_1}{2.10 \times 0.896d} = 0.535\ \frac{M_1}{d}\ cm^2$$

if M_1 is in T-m and d in meters

$$As_2 = \frac{M_2}{2.10(d - d')} = 0.476\ \frac{M_2}{(d - d')}\ cm^2$$

if M_2 is in T-m and d in meters

$$A's = \frac{As_2}{2} \cdot \frac{(1-0.312)}{(0.312 - \frac{d'}{d})} = \frac{As_2}{2} \times \frac{0.688}{(0.312 - \frac{d'}{d})}\ cm^2$$

if M_1 is T-m and d in meters.

11. Bond Coefficients

a. Mild and High Strength Steel

$$\Sigma o = \frac{V}{ujd} = \frac{V \times 100}{(0.10 \times 2630) \times 7/8\ d}$$

$$= 0.435 \frac{V}{d} \text{ cms}$$

if V is in T and d in meters

12. Examples

This item aims in calculating the coefficients for the slabs and beams.

a. Slabs

d = 27 cm = 0.27 m.

using mild steel

$$As_1 = 0.825 \frac{M_1}{0.27} = 3.05\ M_1 \quad cm^2$$

$$As_2 = \frac{M_2}{1.40\ (0.27 - 0.03)} = 2.97\ M_2 \quad cm^2$$

$$A's = \frac{As_2}{2} \left(\frac{0.595}{0.405 - \frac{0.03}{0.27}}\right) = 1.01\ As_2 \quad cm^2$$

$$\Sigma o = 0.435 \frac{V}{0.27} = 1.61\ V \quad cms.$$

b. Frame Beams

Using high strength steel

The various coefficients are calculated below for the five cases available with d' = 8 cms in the case of one row and d' = 12 cms in the case of two rows of reinforcement.

Floor	As_1=CM				As_2 = CM	
	One Row		Two Rows		One Row	
	d(m)	C	d(m)	C	(d-d')(M)	C
20-17	0.52	1.03	0.48	1.11	0.44	1.08
16-13	0.62	0.862	0.58	0.925	0.54	0.88
12-9	0.72	0.742	0.68	0.790	0.64	0.744
8-5	0.82	0.652	0.78	0.688	0.74	0.644
4-1	0.92	0.582	0.88	0.610	0.84	0.566

The values of the resisting moments at <u>supports</u> will be

Floor	Negative Moment					Positive Moment				
	b' (m)	d (m)	d^2 (m^2)	Kb' (T/m^2)	MR (T-m)	b' (m)	d (m)	d^2 (m^2)	Kb (T/m^2)	MR (T-m)
20-17	0.30	0.48	0.232	49.50	13.50	1.30	0.48	0.232	214	49.50
16-13	"	0.58	0.340	"	19.20	"	0.58	0.340	"	72.50
12-9	"	0.68	0.465	"	25.80	"	0.68	0.465	"	99.20
8-5	"	0.78	0.610	"	33.60	"	0.78	0.610	"	130.00
4-1	"	0.88	0.780	"	42.00	"	0.88	0.780	"	167.00

PART A

DESIGN OF A TYPICAL FLOOR

General:

Although it is the regular practice (i.e. more economical) to design slabs with the ribs parallel to the short direction if the slab is one way, and to have slabs as two ways when square, in the present case all slabs will be designed as one way and with ribs parallel to the long direction in order to load the short direction beams with the vertical load, and hence to relieve the long direction beams to take care of the wind loading which is supposed to have a high intensity.

The approximate coefficients provided by the A.C.I. Code cannot be used for two reasons:

1. The longer span is exceeding the shorter spans by more than 20%.
2. The presence of the two cantilevers.

However, two methods of analysis are considered satisfactory, namely:

1. Three Moments Equations.
2. Moment Distribution.

The three moment equations will be used, assuming simple supports.

Moments and Shears:

In order to eliminate some calculations, a general equation is derived with a uniform load w.

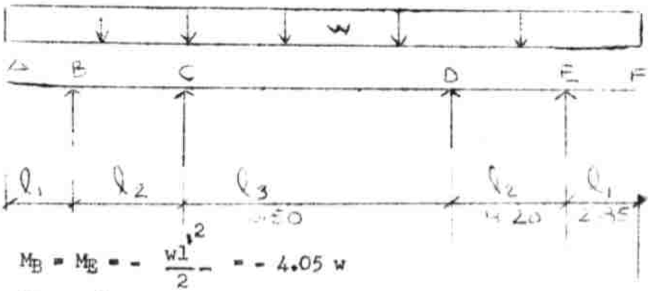

Fig 1

$M_B = M_E = - \frac{wl_1^2}{2} = - 4.05\ w$

$M_C = M_D$

$M_B . l_2 + 2M_C (l_2 + l_3) + M_C . l_3 = - \frac{w}{4} (l_2^3 + l_3^3)$

$(-4.05\ w)\ 4.20 + 2M_C(10.70) + 6.50\ M_C = - \frac{w}{4} (74 + 274)$

$- 17w + 21.40\ M_C + 6.50\ M_C = \frac{w}{4} \times 348 = - 87\ w$

$- 17w + 27.90\ M_C = - 87\ w$

$27.90\ M_C = - 70\ w$

$M_C = - \frac{70}{27.90} w = - 2.50\ w$

$M_C = 4.20\ R_B - w \times \frac{\overline{7.05}^2}{2} = - 2.50\ w$

$4.20\ R_B - 25\ w = - 2.50\ w$

$4.20\ R_B = + 22.50\ w$

$R_B = + \frac{22.50}{4.20}\ w = + 5.35\ w$

$M_D = 10.70\ (5.35\ w) + 6.50\ R_C - w \times \frac{\overline{13.55}^2}{2} = - 2.50\ w$

$57.20\ w + 6.50\ R_C - 92\ w = - 2.50\ w$

$6.50\ R_C = (-2.50 + 92 - 57.20)w$

$R_C = \frac{32.30\ w}{6.50} = 4.95\ w$

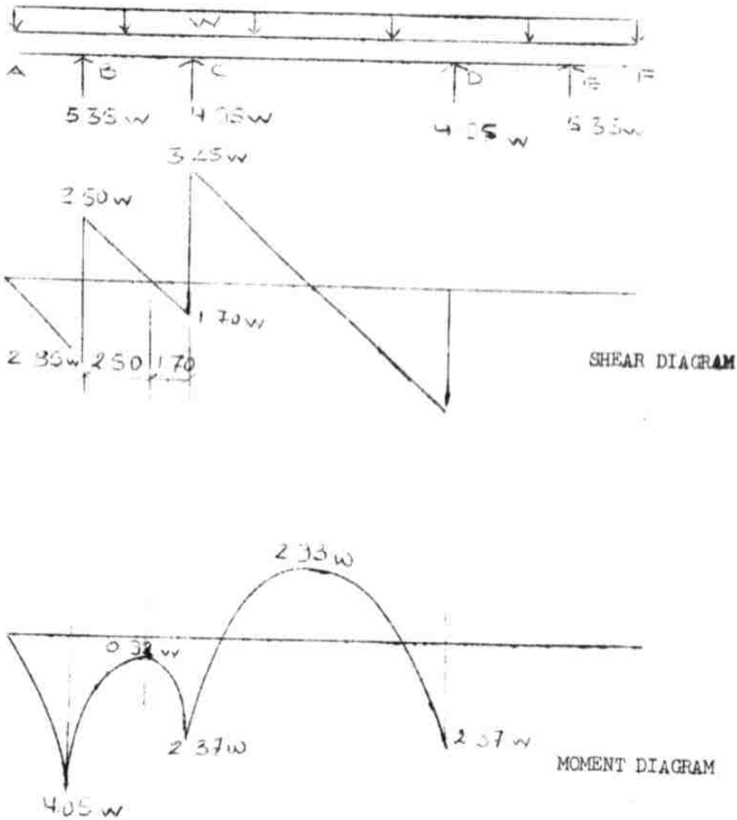

Fig 2

Loading:

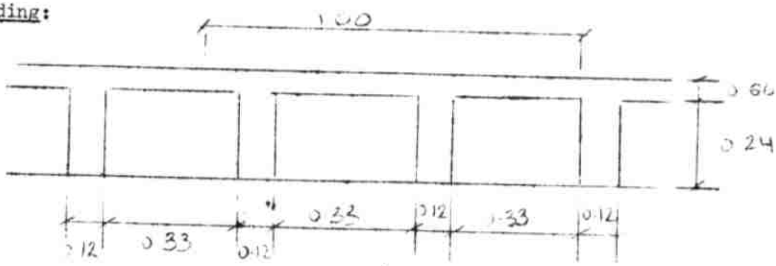

Fig 3.

Live Load	250 Kg/m^2
D.L. of 6 cms. Slab	150 Kg/m^2
Tiles and mortar 3 cms	
0.03 x 2400	72 Kg/m^2
Sand 4 cms	
0.04 x 1800	72 Kg/m^2
2 cms Plaster	48 Kg/m^2
Blocks (12 x 13)	156 Kg/m^2
Joists	
(0.12x0.24x2500)2	144 Kg/m^2
Partitions:	100 Kg/m^2
	992 Kg/m^2
	Say $1^T/m^2$

Load / Rib = 0.50 T/m^2

From the shear diagram

$$V_{max} = 3.25\ w = 3.25 \times 500 = 1625\ Kg.$$

$$b'(rqd) = \frac{1625}{8 \times 7/8 \times 27} = \frac{1625}{168} = 9.70\ cms \quad \therefore\ O.K.$$

$$M_C\ (Support) = 207 \times 0.12 \times \overline{0.27}^{\,2} = 1.43\ T\text{-}m$$

$$M_C\ (Center) = 207 \times 0.45 \times \overline{0.27}^{\,2} = 5.35\ T\text{-}m$$

Reinforcement:

1. First Mid-Span

$M_1 = 0.92 \times 0.50 = 0.46$ T-m

$M_C > M_1$ i.e. $5.35 > 0.46$

$A_s = 3.05 \times 0.46 = 1.40$ cm^2

Use 2∅10 mm.

As (fur.) = 1.56 cm^2

2. Second Mid-Span

$M_1 = 2.93 \times 0.50 = 1.47$ T-m

$M_C > M_1$

$A_s = 3.05 \times 1.47 = 4.50$ cm^2

Use 2∅18 mm.

As (fur.) = 5.00 cm^2

3. Interior Supports

$M_1 = 2.37 \times 0.50 = 1.19$ T-m

$M_C > M_1$ i.e. $1.43 > 1.19$

$A_s = 3.05 \times 1.19 = 3.62$ cm^2

Use 1∅22 mm.

As (fur.) = 3.83 cm^2

$\Sigma o = 1.61 \times 1.625 = 2.62$ cms.

$\therefore$ O.K.

4. Exterior Supports

$M = 4.05\,w = 4.05 \times 0.50 = 2.03$ T-m

$M_C = 1.43$ T-m

$As_1 = 3.05\,M_C = 3.05 \times 1.43 = 4.35\ cm^2$

$As_2 = 2.97\ (2.03 - 1.43)$

$= 2.97 \times 0.60 = 1.80$

$A's = 1.01 \times 1.80 = 1.82 \quad As_2$

$As = 4.35 + 1.80 = 6.15\ cm^2$

Use 1Ø30 mm.

As (fur.) $= 7.00\ cm^2$

$\Sigma o = 1.61\ (2.85 \times 0.50) = 2.30$ cms.

$\therefore$ O.K.

PART B

B E A M S

BEAM B_1

1. **Loads:**

Load from slab : $\frac{wl}{2}$

$$1000 \times \frac{4.20}{2} = 2100 \text{ Kg/M.R.}$$

Load from balcony: wl

$$1000 \times 2.85 = 2850 \text{ Kg/M.R.}$$

4950 Kg/M.R.

4.95 T/M.R.

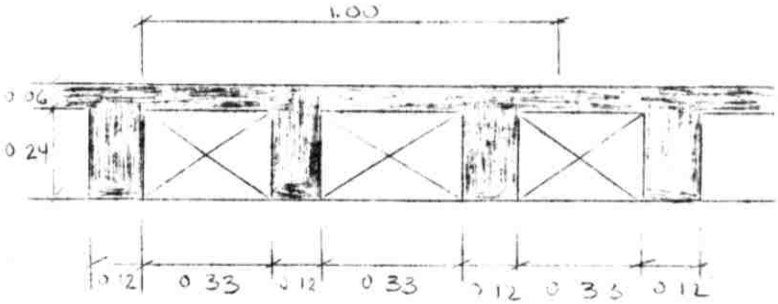

Fig 1

Find the equivalent thickness of the slab:

$$t' = \frac{1 \times 0.06 + 2\,(0.24 \times 0.12)}{1} = 0.1176\text{ m} \approx 12 \text{ cms.}$$

2. <u>Section:</u>

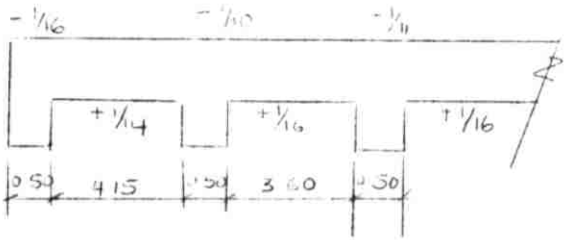

Fig 2

The effective overhang width of an L beam will be the smallest of the following:

a) 1/12 of the beam span = 1/12 x 4.65 x 100 = 39 cms.

b) 6 times slab thickness = 6 x 12 = 72 cms.

c) ½ clear distance to next beam

½ (4.20 - 0.50) = 185 cms.

∴ b" = 39 cms Say 40 cms.

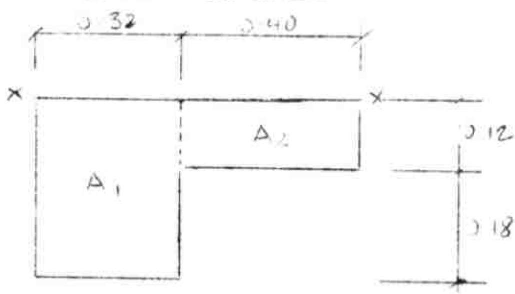

Fig 2

Let the width of the beam be 32 cms.

$\therefore$ D.L. = (0.32 x 0.30 + 0.40 x 0.12) 2500

= (0.096 + 0.048) 2500 = 360 Kg/m

$\therefore w_T$ = 4950 + 360 = 5310 Kg/m

$$V_{max} = 1.15 \frac{wl'}{2} = 1.15 \times \frac{w}{2} \left(\frac{4.15 + 3.60}{2} \right)$$

$$= 1.15 \times \frac{w}{2} \times 3.88$$

$$= 1.15 \times w \times 1.94 = 223w = 11900 \text{ Kg}$$

$$b'd = \frac{11,900}{7/8 \times 16} = \frac{11,900}{14} = 850$$

$$d = 27 \text{ cm} \quad \therefore \quad b' = \frac{850}{27} = 31.50 \text{ cms.}$$

$\therefore$ O.K.

Find the neutral axis by summing moments at x-x

$$\sum M_{xx} = 0$$

$$A\bar{y} = A_1 y_1 + A_2 y_2$$

$$(32 \times 30 + 40 \times 12)\, \bar{y} = (32 \times 30 \times 15) + (40 \times 12 \times 6)$$

$$(960 + 480)\, \bar{y} = 14,400 + 2880$$

$$1440\, \bar{y} = 17,280$$

$$\bar{y} = \frac{17,280}{1440} = 12 \text{ cms}$$

i.e. kd = 12 cms.

Hence the beam could act as a rectangular or T-Beam. For simplicity use the rectangular beam equations.

M_C (Center) = $207 \times 0.72 \times \overline{0.27}^2$ = 12.40 T-m

M_C (Support) = $207 \times 0.32 \times \overline{0.27}^2$ = 5.95 T-m

3. <u>Reinforcement</u>:

a. First Mid-Span

$M = 1/14 \times w \times \overline{4.15}^2 = 1.23\ w = 1.23 \times 5.31 = 6.92$ T-m

$\therefore M < M_R$ i.e. $7.90 < 13.40$

$A_s = 3.05\ M_1 = 3.05 \times 6.92 = 20\ cm^2$

Use 4Ø28 mm

As (fur.) = $24.40\ cm^2$

Bend up two bars

b. Other Mid-Spans

$M = 1/16 \times w \times \overline{3.60}^2 = 0.81\ w = 0.81 \times 5.31 = 4.30$ T-m

$M_R > M$ i.e. $13.40 > 4.30$

$A_s = 3.05 \times 4.30 = 13.10\ cm^2$

Use 4Ø20 mm

As (fur.) = $12.56\ cm^2$

Bend up two bars

c. First Interior Support

$M = 1/10\ wl^2$

$= 1/10 \times w \times \overline{3.88}^2 = 1.50\ w = 1.50 \times 5.31 = 7.96$ T-m

$M > M_C$ i.e. $7.96 > 5.95$

$As_1 = 3.05 \times 5.95 = 18.20\ cm^2$

$A_{s_2} = 2.97\ (7.96 - 5.95)$

$= 2.97 \times 2.01 = 5.94\ cm^2$

$A_s = 18.20 + 5.94 = 24.14\ cm^2$

$A'_s = 1.01\ A_{s_2} = 6\ cm^2$

$A_s\ (fur.) = 12.20 + 6.55 = 18.75\ cm^2$

Add 2∅20 mm

$\Sigma o = 1.61 \times 11.90 = 19.10\ cms$

$\Sigma o\ (fur.) = 25.52 + 17.60 = 43.12\ cms.$

d. Other Interior Support

$M = 1/11\ wl^2 = 1/11 \times w \times \overline{3.60}^2 = 1.18\ w$

$= 1.18 \times 5.31 = 6.25\ T\text{-}m$

$M > M_C$ i.e. $6.25 > 5.95\ T\text{-}m$

$A_{s_1} = 3.05 \times 5.95 = 18.20\ cm^2$

$A_{s_2} = 2.97\ (6.25 - 5.95) = 0.89\ cm^2$

$A_s = 18.20 + 0.89 = 19.09\ cm^2$

$A'_s = 1.01 \times 0.89 = 0.90\ cm^2$

$A_s\ (fur.) = 12.56\ cm^2$

Add 2∅22 mm

$V = \frac{wl'}{2} = 5.310 \times \frac{3.60}{2} = 9.55\ T$

$\Sigma o = 1.61 \times 9.55 = 15.40\ cms$

$\Sigma o\ (fur.) = 38.92\ cms$

e. Exterior Support

$M = 1/16 \times w \times \overline{4.15}^2 = 1.03\ w$

$= 1.03 \times 5.31 = 5.50$ T-m

$M < M_C$ i.e. $5.50 < 5.95$

$A_s = 5.95 \times 3.05 = 16.80\ cm^2$

A_s (fur.) $= 12.20\ cm^2$

Add 2Ø18 mm

Σo (fur.) is ample

BEAM B_2

1. **Loads:**

Load from Slab: $1000(\frac{4.20}{2} + \frac{6.50}{2}) = 5360$ Kg/M.R.

The width of the T-Beam will be the smallest of the following:

a) 1/4 of Beam Span = 1/4 x 4.65 x 100 = 114 cms.

b) 16 times slab thickness + b'

i.e. 16 x 10 + 60 = 220 cms.

c) Beam Spacing = $\frac{4.20 + 6.50}{2}$ = 535 cms.

$\therefore$ 114 cms. governs

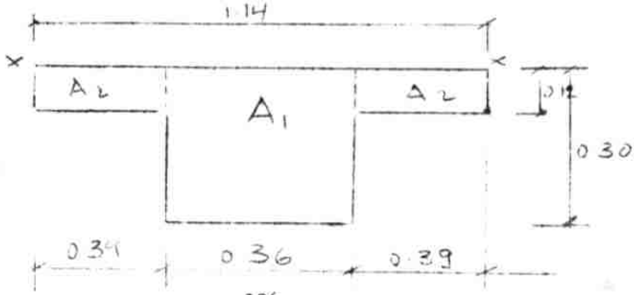

Fig 3

$D.L. = (0.36 \times 0.30 + 0.39 \times 0.12 \times 2)\ 2500$

$= (0.108 + 0.094) \times 2500 = 0.202 \times 2500 = 505\ Kg/M$

$W_T = 5350 + 505 = 5855\ Kg/M$

$V_{max} = 5855 \times 2.23 = 13100\ Kg.$

$$b'd = \frac{13,100}{7/8 \times 16} = 935\ cm^2$$

$d = 27$ cms. $\qquad b' = \frac{935}{27} = 35$ cms.

$\therefore$ O.K.

Find the neutral axis by summing moment at x-x.

$(36 \times 30 + 39 \times 12 \times 2)\ kd = 1080 \times 15 + 940 \times 6$

$(1080 + 940)\ kd = 16,200 + 5640$

$2020\ kd = 21,840$

$$kd = \frac{21,840}{2020} = 1090\ \text{cms.}$$

$\therefore$ It acts as a rectangular beam

M_C (Center) $= 207 \times 1.14 \times \overline{0.27}^2 = 21.20$ T-m

M_B (Support) $= 207 \times 0.36 \times \overline{0.27}^2 = 6.70$ T-m

2. Reinforcement:

a. First Mid-Span

$M = 1.23\ w = 1.23 \times 5.855 = 7.20$ T-m

$M < M_C$ i.e. $7.20 < 21.20$

$A_s = 3.05 \times 720 = 22\ cm^2$

Use 4ø28 mm $\qquad A_s$ (fur.) $= 24.40\ cm^2$

Bend up two bars.

$D.L. = (0.36 \times 0.30 + 0.39 \times 0.12 \times 2)\ 2500$

$= (0.108 + 0.094) \times 2500 = 0.202 \times 2500 = 505$ Kg/M

$W_T = 5350 + 505 = 5855$ Kg/ M

$V_{max} = 5855 \times 2.23 = 13100$ Kg.

$$b'd = \frac{13,100}{7/8 \times 16} = 935 \text{ cm}^2$$

d = 27 cms. $\qquad b' = \frac{935}{27} = 35$ cms.

$\therefore$ O.K.

Find the neutral axis by summing moment at x-x.

$(36 \times 30 + 39 \times 12 \times 2)\ kd = 1080 \times 15 + 940 \times 6$

$(1080 + 940)\ kd = 16,200 + 5640$

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2. Reinforcement:

a. First Mid-Span

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$M < M_C$ i.e. $7.20 < 21.20$

$A_s = 3.05 \times 720 = 22 \text{ cm}^2$

Use 4Ø28 mm $\qquad A_s$ (fur.) $= 24.40 \text{ cm}^2$

Bend up two bars.

b. Other Mid-Spans

$M = 0.81\ w = 0.81 \times 5.855 = 4.75$ T-m

$M < M_C$ i.e. $4.75 < 21.20$

$As = 3.05 \times 4.75 = 14.50\ cm^2$

Use 4∅22 mm As (fur.) = $15.32\ cm^2$

Bend up two bars.

c. First Interior Support

$M = 1.50\ w = 1.50 \times 5.855 = 8.80$ T-m

$M > M_C$ i.e. $8.80 > 6.70$

$As_1 = 3.05 \times 6.70 = 20.50\ cm^2$

$As_2 = 2.97\ (8.80-6.70) = 6.22\ cm^2$

$A_s = 20.50 + 6.22 = 26.72\ cm^2$

$A_s' = 1.01 \times 6.22 = 6.30\ cm^2$

As (fur.) = 19.88 cm2

Add 2∅22 mm

$\Sigma o = 13.10 \times 1.61 = 25.80$ cm.

Σo (fur.) = 45.20 cms.

d. Other Interior Supports

$M = 1.18\ w = 1.18 \times 5.855 = 6.90$ T-m

$\therefore\ M > M_C$ i.e. $6.90 > 6.70$

$As_1 = 20.50\ cm^2$

$As_2 = 2.97 \times 0.20 = 0.59\ cm^2$

$A_s = 20.50 + 0.59 = 21.09\ cm^2$

$A'_s = 1.01 \times 0.59 = 0.60\ cm^2$

A_s (fur.) = $15.32\ cm^2$

Add 2ø18 mm

$V = 5.85 \times 1.80 = 10.50$ T

$\Sigma o = 10.50 \times 1.61 = 16.90$ cms

Σo (fur.) = 38.90 cms.

e. Exterior Support

$M = 1.03 \times 5.85 = 6.02$ T-m $<$ 6.90 T-m

$A_s = 3.05 \times 6.02 = 18.40\ cm^2$

A_s (fur.) = $12.20\ cm^2$

Add 2ø20 mm

Σo (fur.) is ample

Critical Frame Beams:

1. Loads Acting:

The loads are:

a. D.L. of Beams.

b. Partitions.

c. Plaster, sand, tiles, etc.

d. Load from slab.

e. Live loads.

The first four items are existing at any time and constitute the major part of the vertical loading .Hence two separate analyses are not rendered necessary.

The basis of the calculation is run below for the four top beams.

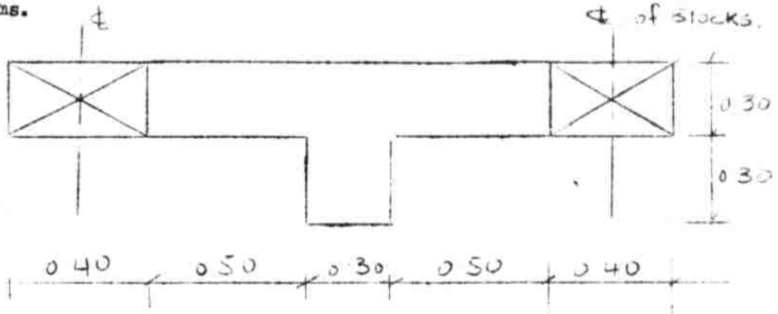


Fig 4

D.L. = 0.48 x 2.50 = 1.20 T/m

Partitions = 0.50 T/m

Load from slab = 0.40 T/m

Plaster, sand, tiles, etc. = 0.20 x 1.20 = 0.24 T/m

Live Load = 0.25 x 1.20 = 0.30 T/m

---

w_T = 2.64 T/m

Floors	Area m^2	D.L. 2.50 T/m^2 (T/m)	Partitions (T/m)	Load from Slab (T/m)	Plaster, Tiles Sand, etc. (T/m)	Live Load T/m	Total Load T/m	F.E.M. Ext. Span $l^2/12$	F.E.M. Ext. Span $wl^2/12$	F.E.M. Mid. Span $l^2/12$	F.E.M. Mid. Span $wl^2/12$
20-17	0.48	1.20	0.50	0.40	0.24	0.30	2.64	1.47	3.90	3.52	9.30
16-13	0.51	1.27	0.50	0.40	0.24	0.30	2.71	1.47	4.00	3.52	9.50
12-9	0.54	1.35	0.50	0.40	0.24	0.30	2.79	1.47	4.10	3.52	9.80
8-5	0.57	1.42	0.50	0.40	0.24	0.30	2.86	1.47	4.20	3.52	10.10
4-1	0.60	1.50	0.50	0.40	0.24	0.30	2.94	1.47	4.30	3.52	10.30

2. **Distribution Factors:**

Joint	Kc S	Kg_1 L	Kg_2(Mod) R	Kc I	K	Distribution Factors S	L	R	I
2Ca	0	24.00	7.70	7.70	39.40	0	0.60	0.20	0.20
19,18,17	7.70	24.00	7.70	7.70	47.10	0.17	0.51	0.16	0.16
16	7.70	37.30	12.10	26.40	83.50	0.09	0.45	0.14	0.32
15,14,13	26.40	37.30	12.10	26.40	102.20	0.26	0.36	0.12	0.26
12	26.40	55.80	18.00	62.50	162.70	0.16	0.34	0.11	0.39
11,10,9	62.50	55.80	18.00	62.50	198.80	0.31	0.28	0.09	0.32
8	62.50	79.00	25.50	122.00	289.00	0.22	0.27	0.09	0.42
7,6,5	122.00	79.00	25.50	122.00	348.50	0.35	0.23	0.07	0.35
4	122.00	108.00	35.00	211.00	476.00	0.26	0.23	0.07	0.44
3	211.00	108.00	35.00	211.00	565.00	0.37	0.19	0.07	0.37
2	211.00	108.00	35.00	147.00	501.00	0.42	0.22	0.07	0.29
1	147.00	108.00	"	160.00	450.00	0.33	0.24	0.08	0.35

JOINT	0	1			2			3			4			5			6			7		
MEMBER	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S
DIST. FACTOR	0	0.39	0.26	0.35	0.32	0.23	0.45	0.40	0.20	0.40	0.48	0.24	0.28	0.58	0.24	0.38	0.38	0.24	0.38	0.38	0.24	0.38
			-4.30			-4.30			-4.30			-4.30			-4.70			-4.20			-4.20	

JOINT	8			9			10			11			12			13			14		
MEMBER	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S
DIST. FACTOR	0.46	0.30	0.24	0.34	0.32	0.34	0.34	0.32	0.34	0.34	0.32	0.34	0.43	0.39	0.18	0.29	0.42	0.29	0.29	0.42	0.29
		-4.20			-4.10			-4.10			-4.10			-4.10			-4.00			-4.00	

JOINT	15			16			17			18			19			20		
MEMBER	I	R	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R	–
DIST. FACTOR	0.29	0.42	0.29	0.37	0.52	0.11	0.20	0.60	0.20	0.20	0.60	0.20	0.20	0.60	0.20	0.20	0.76	–
		-4.00			-4.00			-3.90			-3.90			-3.90			-3.90	

JOINT	20a				19a				18a				14a				16a				15a				14a			
MEMBER	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S
DIST. FACTOR	0.60	0.20	0.20	0.17	0.51	0.16	0.16	0.17	0.51	0.16	0.16	0.17	0.51	0.16	0.16	0.09	0.45	0.12	0.32	0.26	0.36	0.12	0.26	0.26	0.36	0.12	0.20	[illegible]
	+3.90	-9.30			+3.90	-9.30			+3.90	-9.30			+3.90	-9.50			+4.00	-9.50			+4.00	-9.50			+4.00	-9.51		

Joint		18			19			20	
	I	R	S	I	R	S	I	R	–
D.F.	0.20	0.60	0.20	0.20	0.60	0.20	0.20	0.76	–
F.E.M.		-3.90			-3.90			-3.90	

Joint	20a				19a				18a				14a			
	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S
D.F.	0.60	0.20	0.20	0.17	0.51	0.16	0.16	0.17	0.51	0.16	0.16	0.17	0.51	0.16	0.16	0.09
F.E.M.	+3.90	-9.30			+3.90	-9.30			+3.90	-9.30			+3.90	-9.30		

Joint	16a				15a				14a				13a			
	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S
D.F.	0.45	0.12	0.38	0.26	0.36	0.12	0.26	0.26	0.36	0.12	0.20	0.26	0.36	0.12	0.20	0.16
F.E.M.	+4.00	-9.50			+4.00	-9.50			+4.00	-9.50			+4.00	-9.50		

Joint	12a				11a				10a				9a			
	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S
D.F.	0.34	0.11	0.39	0.31	0.28	0.09	0.32	0.31	0.28	0.09	0.32	0.31	0.28	0.09	0.32	0.22
F.E.M.	+4.10	-9.80			+4.10	-9.80			+4.10	-9.80			+4.10	-9.80		

Joint	8a				7a				6a				5a			
	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S
D.F.	0.27	0.09	0.42	0.35	0.23	0.07	0.35	0.35	0.23	0.07	0.35	0.35	0.28	0.07	0.35	0.26
F.E.M.	+4.20	-10.10			+4.20	-10.10			+4.20	-10.10			+4.20	-10.10		

Joint	4a				3a				2a				1a			0
	L	R	I	S	L	R	I	S	L	R	I	S	L	R	I	S
D.F.	0.23	0.07	0.44	0.37	0.19	0.07	0.37	0.42	0.22	0.07	0.28	0.33	0.24	0.08	0.35	0
F.E.M.	+4.30	-10.30			+4.30	-10.30			+4.30	-10.30			+4.30	-10.30		

ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER : RIAD SHAHIN		VERTICAL LOAD ANALYSIS
CHK'D BY : RIAD SHAHIN		HARDY CROSS METHOD
APP'D BY : D. JACK NASSER	DATE: DECEMBER 1964	SHEET Nº 133 /

3. Maximum Positive Moment:

Joint	w T/m	Exterior Span $l^2/8$	Exterior Span $wl^2/8$	Exterior Span $2xwl^2/8$	Exterior Span a	Exterior Span b	Middle Span $l^2/8$	Middle Span $wl^2/8$	Middle Span $2xwl^2/8$	Middle Span a=b	Max. Positive Moment $(wl^2/8 - \frac{a+b}{2} = (wl^2/8 - a)$
20	2.64	2.21	5.82	11.64	0.80	7.20	5.30	14.00	28.00	8.40	14-8.40=5.60
19	"	"	"	"	1.60	6.70	"	"	"	8.70	14-8.70=5.30
18	"	"	"	"	1.60	6.70	"	"	"	8.60	14-8.60=5.40
17	"	"	"	"	1.50	6.90	"	"	"	8.70	14-8.70=5.30
16	2.71	"	6.00	12.00	1.80	6.60	"	14.30	28.60	8.90	14.30-8.90=5.40
15	"	"	"	"	2.30	6.00	"	"	"	9.10	14.30-9.10=5.20
14	"	"	"	"	2.30	6.00	"	"	"	9.00	14.30-9.00=5.30
13	"	"	"	"	2.20	6.20	"	"	"	9.10	14.30-9.10=5.20
12	2.79	"	6.18	12.36	2.50	6.10	"	14.80	29.60	9.40	14.80-9.40=5.40
11	"	"	"	"	2.80	5.60	"	"	"	9.50	14.80-9.50=5.30
10	"	"	"	"	2.80	5.70	"	"	"	9.50	14.80-9.50=5.30
9	"	"	"	"	2.70	5.70	"	"	"	9.40	14.80-9.40=5.40
8	2.86	"	6.32	12.64	2.90	5.80	"	15.10	30.20	9.70	15.10-9.70=5.40
7	"	"	"	"	3.10	5.50	"	"	"	9.80	15.10-9.80=5.30
6	"	"	"	"	3.00	5.60	"	"	"	9.80	15.10-9.80=5.30
5	"	"	"	"	3.10	5.60	"	"	"	9.80	15.10-9.80=5.30
4	2.94	"	6.52	13.04	3.20	5.70	"	15.60	31.20	10.00	15.60-10.00=5.60
3	"	"	"	"	3.40	5.40	"	"	"	10.00	15.60-10.00=5.60
2	"	"	"	"	3.20	5.60	"	"	"	10.00	15.60-10.00=5.60
1	"	"	"	"	3.00	5.90	"	"	"	9.90	15.60-9.90=5.70

N.B.- All moments are in T-m.
- a and b are end moments.

4. Moment in Columns Due to Vertical Loading:

Story	Exterior Columns		Interior Side	
	Upper Side T-m	Lower Side T-m	Upper Side T-m	Lower Side T-m
20	0.80	0.80	1.20	1.10
19	0.80	0.80	0.90	0.90
18	0.80	0.80	1.00	1.00
17	0.70	0.60	0.80	0.60
16	1.20	1.20	1.70	1.70
15	1.10	1.20	1.40	1.50
14	1.10	1.20	1.50	1.60
13	1.00	0.90	1.30	1.10
12	1.60	1.50	2.20	2.00
11	1.30	1.40	1.90	1.90
10	1.40	1.40	1.90	1.90
9	1.30	1.20	1.80	1.50
8	1.70	1.70	2.40	2.20
7	1.40	1.60	2.10	2.00
6	1.40	1.60	2.20	2.20
5	1.50	1.40	2.00	1.80
4	1.80	1.80	2.50	2.30
3	1.60	1.70	2.30	2.40
2	1.50	1.70	2.00	2.20
1	1.30	1.70	1.80	0.90

5. Shear Equations

a. Vertical Loading

$$R_1 = \frac{wl}{2} + \frac{(M_1 + M_2)}{l}$$

$$R_2 = \frac{wl}{2} - \frac{(M_1 + M_2)}{l}$$

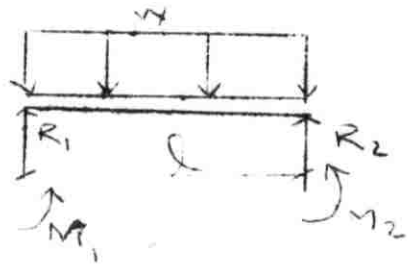


Fig 5

The signs of moments are already taken care of.

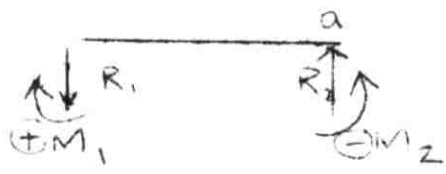
b. Wind From Left

$$M_a = 0$$

$$(M_1 - M_2) - R_1 l = 0$$

$$R_1 = \frac{+(M_1 - M_2)}{l}$$

$$R_2 = \frac{-(M_1 - M_2)}{l}$$



$M_1 > M_2$

Fig. 6

c. Wind From Right

$$R_1 = \frac{-(M_1 - M_2)}{l}$$

$$R_2 = \frac{+(M_1 - M_2)}{l}$$

Again signs are taken care of.

6. Shears Due to Vertical Loading:

a. Exterior Support

Floor	M_1 (T-m)	M_2 (T-m)	(M_1+M_2) (T-M)	$\frac{M_1+M_2}{l}$ (T-m)	$\frac{wl}{2}$ (T-m)	R_1 (T)	R_2 (T)
20	0.80	7.20	8.00	1.90	5.55	7.45	3.65
19	1.60	6.70	8.30	2.00	5.55	7.55	3.55
18	1.60	6.70	8.30	2.00	5.55	7.55	3.55
17	1.50	6.90	8.40	2.00	5.55	7.55	3.55
16	1.80	6.60	8.40	2.00	5.70	7.70	3.70
15	2.30	6.00	8.30	2.00	5.70	7.70	3.70
14	2.30	6.00	8.30	2.00	5.70	7.70	3.70
13	2.20	6.20	8.40	2.00	5.70	7.70	3.70
12	2.50	6.10	8.60	2.05	5.85	7.90	3.80
11	2.80	5.60	8.40	2.00	5.85	7.85	3.85
10	2.80	5.70	8.50	2.05	5.85	7.90	3.80
9	2.70	5.70	8.40	2.00	5.85	7.85	3.85
8	2.90	5.80	8.70	2.08	6.00	8.08	3.92
7	3.10	5.50	8.60	2.05	6.00	8.05	3.95
6	3.00	5.60	8.60	2.05	6.00	8.05	3.95
5	3.10	5.60	8.70	2.08	6.00	8.08	3.92
4	3.20	5.70	8.90	2.10	6.15	8.25	4.05
3	3.40	5.40	8.80	2.10	6.15	8.25	4.05
2	3.20	5.60	8.80	2.10	6.15	8.25	4.05
1	3.00	5.90	8.90	2.10	6.15	8.25	4.05

b. Interior Support

Floor	M_1 (T-m)	$2M_1$ (T-m)	$\frac{2M_1}{l}$ (T-m)	$\frac{wl}{2}$ (T-m)	R'_2 (T)
20	8.40	16.80	2.60	8.60	11.20
19	8.70	17.40	2.70	8.60	11.30
18	8.60	17.20	2.65	8.60	11.25
17	8.70	17.40	2.70	8.60	11.30
16	8.90	17.80	2.75	8.80	11.55
15	9.10	18.20	2.80	8.80	11.60
14	9.00	18.00	2.77	8.80	11.57
13	9.10	18.20	2.80	8.80	11.60
12	9.40	18.80	2.88	9.05	11.93
11	9.50	19.00	2.90	9.05	11.95
10	9.50	19.00	2.90	9.05	11.95
9	9.40	18.80	2.88	9.05	11.93
8	9.70	19.40	2.98	9.25	12.23
7	9.80	19.60	3.00	9.25	12.25
6	9.80	19.60	3.00	9.25	12.25
5	9.80	19.60	3.00	9.25	12.25
4	10.00	20.00	3.05	9.55	12.60
3	10.00	20.00	3.05	9.55	12.60
2	10.00	20.00	3.05	9.25	12.60
1	9.90	19.80	3.02	9.25	11.57

7. <u>Shears due to Wind From Left</u>

a. Exterior Supports

Floor	M_1 (T-m)	M_2 (T-m)	M_1-M_2 (T-m)	R_1 (T)	R_2 (T)
20	0.76	0.63	0.13	-0.03	+0.03
19	2.15	1.76	0.39	-0.09	+0.09
18	4.47	2.89	1.58	-0.38	+0.38
17	4.76	3.74	1.02	-0.24	+0.24
16	5.75	4.99	0.74	-0.18	+0.18
15	7.03	6.10	0.93	-0.22	+0.22
14	8.18	7.03	1.15	-0.27	+0.27
13	8.85	7.50	1.35	-0.32	+0.32
12	9.65	8.59	1.06	-0.25	+0.25
11	11.25	9.89	1.36	-0.32	+0.32
10	11.80	10.92	0.88	-0.21	+0.21
9	12.44	10.43	2.01	-0.50	+0.50
8	13.98	12.80	1.18	-0.28	+0.28
7	15.60	14.43	1.17	-0.28	+0.28
6	16.00	14.72	1.38	-0.33	+0.33
5	16.00	14.48	1.52	-0.36	+0.36
4	17.67	16.18	1.49	-0.35	+0.35
3	22.20	19.43	2.77	-0.66	+0.66
2	41.00	39.27	1.73	-0.41	+0.41
1	43.75	40.53	2.22	-0.52	+0.52

8. <u>Final Shears:</u>

a. Exterior Supports

Floor	Pos. Moment at Exterior Support			Neg. Moment at Exterior Support	
	D.L. (T)	Wind Load (T)	Total Shear (T)	Wind Load (T)	Total Shear (T)
20	+7.45	-0.03	+7.45	+0.03	+7.48
19	+7.55	-0.09	+7.55	+0.09	+7.64
18	+7.55	-.038	+7.55	+0.38	7.93
17	+7.55	-0.24	+7.55	+0.24	7.79
16	+7.70	-0.18	+7.70	+0.18	7.88
15	+7.70	-0.22	+7.70	+0.22	7.92
14	+7.70	-0.27	+7.70	+0.27	7.92
13	+7.70	-0.32	+7.70	+0.32	8.02
12	+7.90	-0.25	+7.90	+0.25	8.15
11	+7.85	-0.32	+7.85	+0.32	8.17
10	+7.90	-0.21	+7.90	+0.21	8.11
9	+7.85	-0.50	+7.85	+0.50	8.35
8	+8.08	-0.28	+8.08	+0.28	8.36
7	+8.05	-0.28	+8.05	+0.28	8.33
6	+8.05	-0.33	+8.05	+0.33	8.38
5	+8.08	-0.36	+8.08	+0.36	8.44
4	+8.25	-0.35	+8.25	+0.35	5.60
3	+8.25	-0.66	+8.25	+0.66	8.91
2	+8.25	-0.41	+8.25	+0.41	8.66
1	+8.25	-0.52	+8.25	+0.52	8.77

b. Interior Supports

Floor	Neg. Moment at Interior Support			Pos. Moment at Interior Support	
	D.L. (T)	Wind Load (T)	Total Load (T)	Wind Load (T)	Total Load (T)
20	+3.65	+0.03	3.68	-0.03	3.65
19	+3.55	+0.09	3.64	-0.09	3.55
18	+3.55	+0.38	3.93	-0.38	3.55
17	+3.55	+0.24	3.79	-0.24	3.55
16	+3.70	+0.18	3.88	-0.18	3.70
15	+3.70	+0.22	3.92	-0.22	3.70
14	+3.70	+0.27	3.97	-0.27	3.70
13	+3.70	+0.32	4.02	-0.32	3.70
12	+3.80	+0.25	4.05	-0.25	3.80
11	+3.85	+0.32	4.17	-0.32	3.85
10	+3.80	+0.21	4.01	-0.21	3.80
9	+3.85	+0.50	4.35	-0.50	3.85
8	+3.92	+0.28	4.20	-0.28	3.92
7	+3.95	+0.28	4.23	-0.28	3.95
6	+3.95	+0.33	4.28	-0.33	3.95
5	+3.92	+0.36	4.28	-0.36	3.92
4	+4.05	+0.35	4.40	-0.35	4.05
3	+4.05	+0.66	4.71	-0.66	4.05
2	+4.05	+0.41	4.46	-0.41	4.05
1	+4.05	+0.52	4.57	-0.52	4.05

FLOOR	MR Support 165 bd2 Neg. Moment (T-m)	MR Support Pos. Mom (T-m)	1st Mid Span M≤MR: M (T-m)	Rft (High strength steel) As (Reqd) Coef. of M	As (Reqd) (cm²)	As (fur) from Support (cm²)	2nd Mid span M≤MR: M (T-m)	Rft (High strength steel) As (Reqd) Coef. of M	As (Reqd) (cm²)	As (fur) from Support (cm²)
1	42.00	167.00	2.50	0.582	1.46	Ample	5.50	0.582	3.20	Ample
2	"	"	"	"	"	"	"	"	"	"
3	"	"	"	"	"	"	"	"	"	"
4	"	"	"	"	"	"	"	"	"	"
5	33.60	130.00	"	0.652	1.63	"	"	0.652	3.58	"
6	"	"	"	"	"	"	"	"	"	"
7	"	"	"	"	"	"	"	"	"	"
8	"	"	"	"	"	"	"	"	"	"
9	25.80	99.20	"	0.742	1.86	"	"	0.742	4.07	"
10	"	"	"	"	"	"	"	"	"	"
11	"	"	"	"	"	"	"	"	"	"
12	"	"	"	"	"	"	"	"	"	"
13	19.20	72.50	"	0.862	2.16	"	"	0.862	4.73	"
14	"	"	"	"	"	"	"	"	"	"
15	"	"	"	"	"	"	"	"	"	"
16	"	"	"	"	"	"	"	"	"	"
17	13.50	49.50	"	1.030	2.57	"	"	1.030	5.63	"
18	"	"	"	"	"	"	"	"	"	"
19	"	"	"	"	"	"	"	"	"	"
20	"	"	"	"	"	"	"	"	"	"

Exterior Support

FLOOR	M (T-m)	Positive Moment (M≤MR) Rft (High Strength Steel) As (Reqd) coef. of M	As (Reqd) (cm²)	As (fur.) Φ	As (fur.) (cm²)	b (cm)	d (cm)	bd (cm²)	$p = \frac{As}{bd}$	K	kd (cm)	6 (cm)	Neg. Moment (M≤MR) Rft. (high strength steel) M (T-m)	As (Reqd.) (cm²)	Af (fur.) Φ	Af (fur.) (cm²)	Positive Moment Bond $\frac{0.435}{d}$	V (T)	Σo (Reqd) cm	Neg Moment Bond V (T)	Σo (Reqd) cm
1	36.50	0.60	22.20	8Φ20	25.12	130	88	11,400	0.0022	0.164	14.50	30	37.30	22.70	8Φ20	25.12	0.483	8.25	4.00	8.77	4.20
2	34.80	"	21.20	8Φ20	25.12	"	"	"	0.0022	0.164	14.50	"	34.00	20.70	8Φ20	25.12	"	"	"	8.60	4.17
3	17.00	"	0.00	8Φ14	12.00	"	"	"	0.00105	0.119	10.50	"	20.10	12.20	8Φ16	16.24	"	"	"	8.81	4.30
4	12.60	"	7.70	8Φ12	9.04	"	"	"	0.0008		Kd<t	"	14.50	8.85	8Φ14	12.00	"	"	"	5.60	2.70
5	11.50	0.688	7.90	8Φ12	9.04	"	78	10,100	0.0008		"	"	15.00	10.30	8Φ14	12.00	0.545	8.08	4.40	8.44	4.60
6	10.60	"	7.95	8Φ12	9.04	"	"	"	0.0008		"	"	15.00	10.30	8Φ14	12.00	"	8.05	"	8.38	4.55
7	11.00	"	7.55	8Φ12	9.04	"	"	"	0.0008		"	"	14.50	9.95	8Φ14	"	"	"	"	8.33	4.50
8	10.10	"	7.00	8Φ12	9.04	"	"	"	0.0008		"	"	13.98	9.60	8Φ14	"	"	8.08	"	8.36	4.50
9	9.00	0.790	7.10	8Φ12	9.04	"	68	8,800	0.001		"	"	12.40	9.80	8Φ14	"	0.625	7.85	4.90	8.35	5.20
10	8.20	"	6.45	8Φ12	9.04	"	"	"	0.001		"	"	11.00	8.70	8Φ14	"	"	7.90	4.93	8.11	5.08
11	7.80	"	6.15	8Φ12	9.04	"	"	"	0.001		"	"	11.50	9.05	8Φ14	"	"	7.85	4.90	8.17	5.10
12	6.60	"	5.20	8Φ10	6.04	"	"	"	0.0007		"	"	10.00	7.90	8Φ12	9.04	"	7.90	4.93	8.15	"
13	6.20	0.925	5.72	8Φ10	6.04	"	58	7,500	0.0008		"	"	9.50	8.80	8Φ12	"	0.732	7.70	5.65	8.02	5.90
14	5.10	"	4.73	8Φ10	6.04	"	"	"	0.0009		"	"	9.00	8.30	8Φ12	"	"	"	"	7.92	5.80
15	4.20	"	3.90	8Φ10	6.04	"	"	"	0.0008		"	"	8.00	7.40	8Φ12	"	"	"	"	7.92	"
16	3.35	"	3.10	8Φ10	6.04	"	"	"	0.0008		"	"	6.00	5.55	8Φ12	6.04	"	"	"	7.88	5.75
17	2.89	1.110	3.20	8Φ10	6.04	"	48	6,230	0.0008		"	"	5.50	6.10	8Φ12	"	0.885	7.55	6.70	7.79	6.90
18	2.10	"	2.33	8Φ10	6.04	"	"						5.50	6.10	8Φ12	"	"	"	"	7.93	7.00
19	0	"	0										3.30	3.65	8Φ12	"	"	"	"	7.64	6.75
20	0	"	0										1.22	1.33	8Φ12	"	"	7.45	6.60	7.48	6.60

Interior Support

FLOOR	Positive Moment (M≤Mc) Rft. (high strength steel) M (T-m)	As (Reqd) (cm²)	As (Reqd) Φ	As (fur) (cm²)	P	K	Kd (cm)	Negative Moment (M≤Mc) Rft. (high strength steel) M (T-m)	As (Reqd) (cm²)	As (fur) Φ	As (fur) (cm²)	Pos. Moment Bond V (T)	Σo (Reqd) (cms)	Neg. Moment Bond V (T)	Σo (cm)
1	31.60	19.30	8Φ20	25.12	0.0022	0.164	14.50	34.50	21.00	8Φ20	25.12	4.05	2.00	4.57	2.20
2	31.10	18.90	8Φ20	25.12	"	"	"	35.60	21.10	"	25.12	"	"	4.46	2.15
3	12.40	7.60	8Φ14	12.00	0.00105	0.119	10.50	18.15	11.10	8Φ14	12.00	"	"	4.71	2.27
4	9.50	5.80	8Φ10	6.04			Kd<t	15.75	9.60	"	"	"	"	4.90	2.12
5	7.65	5.25	8Φ10	"			"	15.80	10.90	"	"	3.92	2.13	4.28	2.33
6	7.90	5.42	8Φ10	"			"	17.20	11.80	"	"	3.95	2.15	4.28	2.53
7	7.55	5.20	8Φ10	"			"	15.50	10.60	"	"	3.95	"	4.23	2.30
8	5.45	3.75	8Φ10	"			"	15.15	10.40	"	"	3.92	2.13	4.20	2.28
9	4.73	3.23	8Φ10	"			"	13.50	10.70	"	"	3.85	2.40	4.35	2.72
10	4.10	3.25	8Φ10	"			"	14.50	11.50	"	"	3.80	2.38	4.01	2.50
11	3.50	2.76	8Φ10	"			"	13.00	10.30	"	"	3.85	2.40	4.17	2.60
12	1.50	1.18	8Φ10	"			"	12.00	9.50	"	"	3.80	2.38	4.05	2.53
13	0.75	0.69	8Φ10	"			"	12.00	11.10	"	"	3.70	2.72	4.02	2.93
14	0.50	0.46	8Φ10	"			"	11.60	11.70	"	"	"	"	3.97	2.90
15	0						"	10.50	9.70	"	"	"	"	3.92	2.85
16	0						"	9.60	8.90	"	"	"	"	3.88	2.80
17	0						"	9.30	10.30	"	"	3.55	3.14	3.79	3.35
18	0						"	8.50	9.40	"	"	"	"	3.43	3.47
19	0						"	7.30	8.10	"	"	"	"	3.64	3.22
20	0						"	8.00	8.85	"	"	"	"	3.68	3.25

N.B. Stirrups are not required.

ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER : RIAD SHAHIN	REINFORCEMENT IN BEAMS	
CHK'D BY : RIAD SHAHIN		
APP'D BY : Dr JACK NASSER	DATE : DECEMBER 1964	SHEET Nº 142/

FLOOR	MR Support 165 bd² Neg Moment (T-m)	MR Support 165 bd² Pos. Mom (T-m)	1st Mid Span M≤MR: M (T-m)	1st Mid Span Rft (High strength steel) As (Reqd) Coef. of M	1st Mid Span As (Reqd) (cm²)	1st Mid Span As (fur.) from Support (cm²)	2nd Mid span M≤MR: M (T-m)	2nd Mid span Rft (High strength steel) As (Reqd) Coef. of M	2nd Mid span As (Reqd) (cm²)	2nd Mid span As (fur.) from Support (cm²)	Exterior Support M (T-m)	Positive Moment (M≤MR) Rft (High Strength Steel) As (Reqd) Coef. of M	As (Reqd) (cm²)	As (fur.) Φ	As (fur.) (cm²)	b (cm)	d (cm)	bd (cm²)	$p = \frac{A_s}{bd}$	K	Kd (cm)	t (cm)
1	42.00	167.10	2.50	0.582	1.46	Ample	5.50	0.582	3.20	Ample	36.50	0.610	22.20	8Φ20	25.12	130	88	11,400	0.0022	0.164	14.50	30
2	"	"	"	"	"	"	"	"	"	"	34.80	"	21.20	8Φ20	25.12	"	"	"	0.0022	0.164	14.50	"
3	"	"	"	"	"	"	"	"	"	"	17.00	"	10.00	8Φ14	12.00	"	"	"	0.00105	0.119	10.50	"
4	"	"	"	"	"	"	"	"	"	"	12.60	"	7.70	8Φ12	9.04	"	"	"	0.0008		Kd<t	"
5	33.60	110.00	"	0.652	1.63	"	"	0.652	3.58	"	8.50	0.688	7.90	8Φ12	9.04	"	78	10,100	0.0008		"	"
6	"	"	"	"	"	"	"	"	"	"	8.60	"	7.95	8Φ12	9.04	"	"	"	0.0008		"	"
7	"	"	"	"	"	"	"	"	"	"	8.00	"	7.55	8Φ12	9.04	"	"	"	0.0008		"	"
8	"	"	"	"	"	"	"	"	"	"	10.10	"	7.80	8Φ12	9.04	"	"	"	0.0008		"	"
9	25.80	99.20	"	0.742	1.86	"	"	0.742	4.07	"	9.00	0.790	7.10	8Φ12	9.04	"	68	9,800	0.001		"	"
10	"	"	"	"	"	"	"	"	"	"	8.20	"	6.45	8Φ12	9.04	"	"	"	0.001		"	"
11	"	"	"	"	"	"	"	"	"	"	7.80	"	6.15	8Φ12	9.04	"	"	"	0.001		"	"
12	"	"	"	"	"	"	"	"	"	"	6.60	"	5.20	8Φ10	6.04	"	"	"	0.0007		"	"
13	19.20	72.50	"	0.862	2.16	"	"	0.862	4.73	"	6.20	0.925	5.72	8Φ10	6.04	"	58	7,500	0.0008		"	"
14	"	"	"	"	"	"	"	"	"	"	5.10	"	4.73	8Φ10	6.04	"	"	"	0.0009		"	"
15	"	"	"	"	"	"	"	"	"	"	4.20	"	3.90	8Φ10	6.04	"	"	"	0.0008		"	"
16	"	"	"	"	"	"	"	"	"	"	3.35	"	3.10	8Φ10	6.04	"	"	"	0.0008		"	"
17	13.50	49.50	"	1.030	2.57	"	"	1.030	5.63	"	2.89	1.110	3.20	8Φ10	6.04	"	48	6,230	0.0008		"	"
18	"	"	"	"	"	"	"	"	"	"	2.10	"	2.33	8Φ10	6.04	"						
19	"	"	"	"	"	"	"	"	"	"	0	"	0									
20	"	"	"	"	"	"	"	"	"	"	0	"	0									

FLOOR	Exterior Neg. Moment (M≤MR) Rft. (high strength steel) M (T-m)	As (Reqd.) (cm²)	As (fur.) Φ	As (fur.) (cm²)	Positive Moment Bond $\frac{0.435}{d}$	V (T)	Σo (Reqd) cm	Neg Moment Bond V (T)	Σo (Reqd) cm	Interior Support Positive Moment (M≤Mc) Rft. (high strength steel) M (T-m)	As (Reqd.) (cm²)	As (fur.) Φ	As (fur.) (cm²)	p	K	Kd (cm)	Negative Moment (M≤Mc) Rft. (high strength steel) M (T-m)	As (Reqd) (cm²)	As (fur.) Φ	As (fur.) (cm²)	Pos. Moment Bond V (T)	Σo (Reqd) (cms)	Neg. Moment Bond V (T)	Σo (cm)
1	37.30	22.70	8Φ20	25.12	0.483	8.25	4.00	8.77	4.20	31.60	19.30	8Φ20	25.12	0.0022	0.164	14.50	34.50	21.00	8Φ20	25.12	4.05	2.00	4.57	2.20
2	34.00	20.70	8Φ20	25.12	"	"	"	8.66	4.17	31.10	18.90	8Φ20	25.12	"	"	"	35.60	21.10	"	25.12	"	"	4.46	2.15
3	20.10	12.20	8Φ16	16.24	"	"	"	8.91	4.30	12.40	7.60	8Φ14	12.00	0.0010	0.119	10.50	18.15	11.10	8Φ14	12.00	"	"	4.71	2.27
4	18.50	8.85	8Φ14	12.00	"	"	"	8.60	4.70	9.50	5.80	8Φ10	6.04			Kd<t	15.75	9.60	"	"	"	"	4.40	2.12
5	15.00	10.30	8Φ14	12.00	0.545	8.08	4.40	8.44	4.60	7.65	5.25	8Φ10	"			"	15.80	10.90	"	"	3.92	2.13	4.28	2.33
6	15.00	10.30	8Φ14	12.00	"	8.05	"	8.38	4.55	7.90	5.42	8Φ10	"			"	17.20	11.80	"	"	3.95	2.15	4.28	2.53
7	14.50	9.95	8Φ14	"	"	"	"	8.33	4.50	7.55	5.20	8Φ10	"			"	15.50	10.60	"	"	3.95	"	4.23	2.30
8	13.98	9.60	8Φ14	"	"	8.08	"	8.36	4.50	5.45	3.75	8Φ10	"			"	15.15	10.40	"	"	3.92	2.13	4.20	2.28
9	12.40	9.80	8Φ14	"	0.625	7.85	4.90	8.35	5.20	4.73	3.73	8Φ10	"			"	13.50	10.70	"	"	3.85	2.40	4.35	2.72
10	11.00	8.70	8Φ14	"	"	7.90	4.93	8.11	5.08	4.10	3.25	8Φ10	"			"	14.50	11.50	"	"	3.80	2.38	4.01	2.50
11	8.50	9.05	8Φ14	"	"	7.85	4.90	8.17	5.10	3.50	2.76	8Φ10	"			"	13.00	11.30	"	"	3.85	2.40	4.17	2.60
12	10.00	7.90	8Φ12	9.04	"	7.90	4.93	8.15	"	1.50	1.18	8Φ10	"			"	12.00	9.50	"	"	3.80	2.38	4.05	2.53
13	9.50	8.80	8Φ12	"	0.732	7.70	5.65	8.02	5.90	0.75	0.69	8Φ10	"			"	12.00	11.10	"	"	3.70	2.73	4.02	2.93
14	9.00	8.30	8Φ12	"	"	"	"	7.82	5.80	0.50	0.46	8Φ10	"			"	11.60	11.70	"	"	"	"	3.97	2.90
15	8.00	7.40	8Φ12	"	"	"	"	7.92	"	0						"	10.50	9.70	"	"	"	"	3.92	2.85
16	6.00	5.55	8Φ12	6.04	"	"	"	7.88	5.75	0						"	9.60	8.90	"	"	"	"	3.88	2.80
17	5.50	6.10	8Φ12	"	0.885	7.55	6.70	7.79	6.90	0						"	9.30	10.30	"	"	3.55	3.14	3.79	3.35
18	5.50	6.10	8Φ12	"	"	"	"	7.93	7.00	0						"	8.50	9.40	"	"	"	"	3.93	3.47
19	3.30	3.65	8Φ12	"	"	"	"	7.64	6.75	0						"	7.30	8.10	"	"	"	"	3.64	3.22
20	1.22	1.33	8Φ12	"	"	7.45	6.60	7.49	6.60	0						"	8.00	8.85	"	"	"	"	3.68	3.25

N.B. Stirrups are not required.

ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER	RIAD SHAHIN	REINFORCEMENT IN BEAMS
CHK'D BY	RIAD SHAHIN	
APP'D BY	Dr JACK NASSER	DATE: DECEMBER 1964 — SHEET No 142/

PART C

CRITICAL FRAME COLUMNS

General:

The sizes of columns have been changed once. In the first case, special effort was made to use the minimum allowable percentage of steel which did not work out properly. In the second case the sections were reduced almost to half which implied the use of high percentages of steel. The basis of the design are:

1. Load from slab = 1 T/m^2
2. Working stresses
   a. Interior Columns : 600 T/m^2
   b. Exterior Columns : 520 T/m^2
   c. Angle Columns : 450 T/m^2

The calculations for the second case are enclosed hereinafter.

Dead Load Analysis:

Story	Section mxm	Area m^2	Height m	Volume m^3	w T/m^3	Weight T
20-17	0.50 x 0.40	0.20	3.40	0.68	2.50	1.70
16-13	0.50 x 0.60	0.30	3.40	1.02	2.50	2.55
12-8	0.50 x 0.80	0.40	3.40	1.36	2.50	3.40
8-4	0.50 x 1.00	0.50	3.40	1.70	2.50	4.25
4-2	0.50 x 1.20	0.60	3.40	2.04	2.50	5.10
2-1	0.50 x 1.20	0.60	4.90	2.94	2.50	7.25
1-0	0.50 x 1.20	0.60	4.50	2.70	2.50	6.75

Load From Slab:

Column	Area m x m	Load T
C_2	$(2.85+4.20) \times \frac{4.10}{2} = 7.05 \times 2.05 = 14.40$	14.40
C_4	$(4.20+6.50) \times \frac{4.10}{2} = 10.70 \times 2.05 = 22$	22

Load From Tank:

$C_4 = 71$ T [1]

$C_2 = 0$

Total Loads / Floor:

Story	Column C_4			Column C_2		
	Load from slab (T)	D.L. (T)	Total (T)	Load from slab (T)	D.L. (T)	Total (T)
20-17	22	1.70	23.70	14.40	1.70	16.10
16-13	22	2.55	24.55	14.40	2.55	16.95
12-9	22	3.40	25.40	14.40	3.40	17.80
8-5	22	4.25	26.25	14.40	4.25	18.65
4-3	22	5.10	27.10	14.40	5.10	19.50
2	22	7.25	29.25	14.40	7.25	21.65
1	22	6.75	28.75	14.40	6.75	21.15

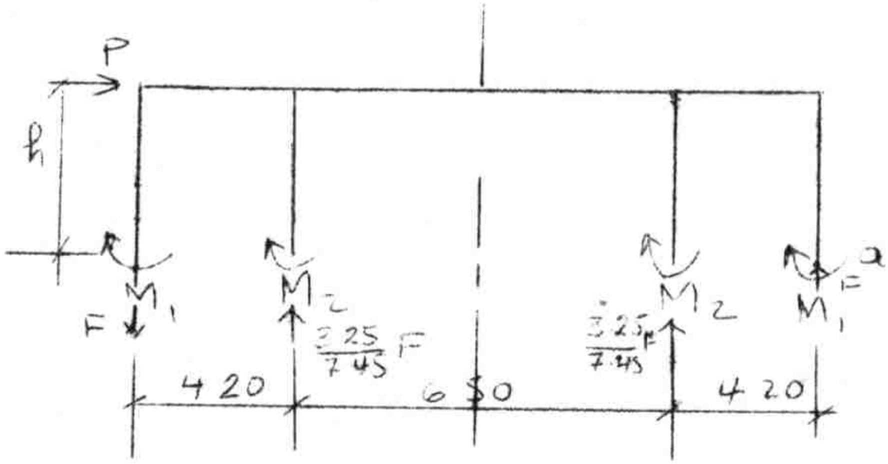
(1) The load from the tank was calculated on the basis of a detailed design of the tank.

Total Loads:

Floor	Column C_4			Column C_2	
	D.L.+Load from slab (T)	Load from Tank (T)	Total (T)	Load From Slab (T)	Total Load (T)
20	23.70	71	23.70+71.00=94.70	16.10	16.10
19			94.70+23.70=118.40		32.20
18			118.40+23.70=142.10		48.30
17			142.10+23.70=165.80		64.40
16	24.55		165.80+24.55=190.35	16.95	81.35
15			190.35+24.55=214.90		98.30
14			214.90+24.55=239.45		115.25
13			239.45+24.55=264.00		132.20
12	25.40		264.00+25.40=289.40	17.80	150.00
11			289.40+25.40=314.80		167.80
10			314.80+25.40=340.20		185.60
9			340.20+25.40=365.60		203.40
8	26.25		365.50+26.25=391.85		222.05
7			391.85+26.25=418.10		240.70
6			418.10+26.25=444.35		259.35
5			444.35+26.25=470.60		278.00
4	27.10		470.60+27.10=497.70	19.50	297.50
3			497.70+27.10=524.80		317.00
2	29.25		524.80+29.25=554.05	21.65	338.65
1	28.75		554.05+28.75=582.80	21.15	359.80

Axial Stresses Due to Wind Loading:

The method adopted assumes that the axial stresses are proportional to their distances from the center of gravity of the structure. Since, the structure is symmetrical, and all columns are of the same dimension the center of gravity coincides with the center of symmetry. The problem then boils down to one of statics.



$\Sigma Ma = 0$

$$Ph - (M_1 + M_2)2 + \frac{3.25}{7.45} \times 4.20F - \frac{3.25}{7.45} \times 10.70\ F - 1490\ F = 0$$

$$Ph - 2(M_1 + M_2) + 1.83\ F - 4.65F - 14.90\ F = 0$$

$$Ph - 2(M_1 + M_2) - 17.72\ F = 0$$

If we have more than one load then:

$$\Sigma Ph - 2(M_1 + M_2) - 17.72\ F = 0$$

$$17.72\ F = \Sigma Ph - 2(M_1 + M_2)$$

$$F = \frac{\Sigma Ph - 2(M_1 + M_2)}{17.72}$$

JOINT	20 P	20 h	20 Ph	19 P	19 h	19 Ph	18 P	18 h	18 Ph	17 P	17 h	17 Ph	16 P	16 h	16 Ph	15 P	15 h	15 Ph
20	1.85	3.40	6.28	1.85	6.80	12.60	1.85	10.20	18.80	1.85	13.60	25.00	1.85	17.00	31.30	1.85	20.40	37.70
19				3.70	3.40	12.60	3.70	6.80	25.20	3.70	10.20	37.70	3.70	13.60	50.20	3.70	17.00	62.50
18							3.65	3.40	12.40	3.65	6.80	24.80	3.65	10.20	37.20	3.65	13.60	49.50
17										3.60	3.40	12.20	3.60	6.80	24.46	3.60	10.20	36.60
16													3.60	3.40	12.20	3.60	6.80	24.40
15																3.50	3.40	11.90
14																		
13																		
12																		
11																		
10																		
9																		
8																		
7																		
6																		
5																		
4																		
3																		
2																		
1																		
ΣPh			6.28			25.20			56.40			99.70			55.80			222.60

JOINT	8 P	8 h	8 Ph	7 P	7 h	7 Ph	6 P	6 h	6 Ph	5 P	5 h	5 Ph	4 P	4 h	4 Ph	3 P	3 h	3 Ph
20	1.85	44.20	81.20	1.85	47.60	87.50	1.85	51.00	93.80	1.85	54.40	100.00	1.85	57.80	106.00	1.85	61.20	113.00
19	3.70	40.80	151.00	3.70	44.20	163.00	3.70	47.60	176.00	3.70	51.00	188.00	3.70	54.40	200.00	3.70	57.80	213.00
18	3.65	37.40	136.00	3.65	40.80	149.00	3.65	44.20	161.00	3.65	47.60	173.00	3.65	51.00	186.00	3.65	54.40	198.00
17	3.60	34.00	122.00	3.60	37.40	134.00	3.60	40.80	147.00	3.60	44.20	159.00	3.60	47.60	171.00	3.60	51.00	183.00
16	3.60	30.60	110.00	3.60	34.00	122.00	3.60	37.40	134.00	3.60	40.80	147.00	3.60	44.20	159.00	3.60	47.60	171.00
15	3.50	27.20	95.00	3.50	30.60	107.00	3.50	34.00	119.00	3.50	37.40	131.00	3.50	40.80	143.00	3.50	44.20	154.00
14	3.40	23.80	80.50	3.40	27.20	92.00	3.40	30.60	103.00	3.40	34.00	115.00	3.40	37.40	127.00	3.40	40.80	139.00
13	3.40	20.40	69.00	3.40	23.80	80.50	3.40	27.20	92.00	3.40	30.60	103.00	3.40	34.00	115.00	3.40	37.40	127.00
12	3.30	17.00	56.00	3.30	20.40	67.20	3.30	23.80	78.40	3.30	27.20	89.60	3.30	30.60	100.80	3.30	34.00	112.00
11	3.20	13.60	43.30	3.20	17.00	54.20	3.20	20.40	65.20	3.20	23.80	76.00	3.20	27.20	86.60	3.20	30.60	97.50
10	3.20	10.20	33.50	3.20	13.60	43.30	3.20	17.00	54.20	3.20	20.40	65.20	3.20	23.80	76.00	3.20	27.20	86.60
9	3.15	6.80	29.00	3.15	10.20	32.00	3.15	13.60	42.70	3.15	17.00	52.30	3.15	20.40	64.20	3.15	23.80	75.00
8	2.90	3.40	9.80	2.90	6.80	19.70	2.90	10.20	29.50	2.90	13.60	39.30	2.90	17.00	49.20	2.90	20.40	59.00
7				2.90	3.40	9.80	2.90	6.80	19.70	2.90	10.20	29.50	2.90	13.60	39.30	2.90	17.00	49.20
6							2.75	3.40	9.30	2.75	6.80	18.70	2.75	10.20	28.00	2.75	13.60	37.30
5										2.60	3.40	8.80	2.60	6.80	17.70	2.60	10.20	26.50
4													2.60	3.40	8.80	2.60	6.80	17.70
3																2.40	3.40	8.20
2																		
1																		
ΣPh			1108.30			1161.20			1324.80			1496.40			1678.20			1867.00

JOINT	14 P	14 h	14 Ph	13 P	13 h	13 Ph	12 P	12 h	12 Ph	11 P	11 h	11 Ph	10 P	10 h	10 Ph	9 P	9 h	9 Ph
20	1.85	23.80	44.00	1.85	27.20	50.00	1.85	30.60	56.20	1.85	34.00	62.50	1.85	37.40	69.00	1.85	40.80	75.20
19	3.70	20.40	75.50	3.70	23.80	88.00	3.70	27.20	100.00	3.70	30.60	113.00	3.70	34.00	125.00	3.70	37.40	138.00
18	3.65	17.00	62.00	3.65	20.40	74.20	3.65	23.80	86.60	3.65	27.20	99.00	3.65	30.60	111.00	3.65	34.00	123.00
17	3.60	13.60	48.80	3.60	17.00	61.00	3.60	20.40	73.50	3.60	23.80	85.60	3.60	27.20	97.50	3.60	30.60	110.00
16	3.60	10.20	36.60	3.60	13.60	48.90	3.60	17.00	61.00	3.60	20.40	73.50	3.60	23.80	85.60	3.60	27.20	97.50
15	3.50	6.80	23.80	3.50	10.20	35.60	3.50	13.60	47.50	3.50	17.00	59.20	3.50	20.40	70.20	3.50	23.80	83.00
14	3.40	3.40	11.50	3.40	6.80	23.00	3.40	10.20	34.50	3.40	13.60	46.80	3.40	17.00	57.50	3.40	20.40	69.00
13				3.40	3.40	11.50	3.40	6.80	23.00	3.40	10.20	34.50	3.40	13.60	46.00	3.40	17.00	57.50
12							3.30	3.40	11.20	3.30	6.80	22.40	3.30	10.20	33.60	3.30	13.60	44.80
11										3.20	3.40	10.80	3.20	6.80	21.70	3.20	10.20	33.50
10													3.20	3.40	10.80	3.20	6.80	21.70
9																3.15	3.40	10.70
8																		
7																		
6																		
5																		
4																		
3																		
2																		
1																		
ΣPh			302.20			392.10			493.50			606.50			727.90			863.90

JOINT	2 P	2 h	2 Ph	1 P	1 h	1 Ph
20	1.85	66.10	121.00	1.85	70.60	130.00
19	3.70	61.20	226.00	3.70	66.10	244.00
18	3.65	57.80	210.00	3.65	61.20	223.00
17	3.60	54.40	195.00	3.60	57.80	207.00
16	3.60	51.00	183.00	3.60	54.40	195.00
15	3.50	47.60	166.00	3.50	51.00	178.00
14	3.40	44.20	150.00	3.40	47.60	161.00
13	3.40	40.80	139.00	3.40	44.20	150.00
12	3.30	37.40	123.00	3.30	40.80	134.20
11	3.20	34.00	108.00	3.20	37.40	120.00
10	3.20	30.60	97.50	3.20	34.00	108.00
9	3.15	27.20	85.20	3.15	30.60	96.50
8	2.90	23.80	69.00	2.90	27.20	78.50
7	2.90	20.40	59.00	2.90	23.80	69.00
6	2.75	17.00	46.60	2.75	20.40	56.20
5	2.60	13.60	35.20	2.60	17.00	46.00
4	2.60	10.20	26.50	2.60	13.60	35.20
3	2.40	6.80	16.30	2.40	10.20	24.40
2	2.70	3.40	9.20	2.70	6.80	18.30
1				1.60	3.40	5.40
ΣPh			2065.50			2279.20

ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

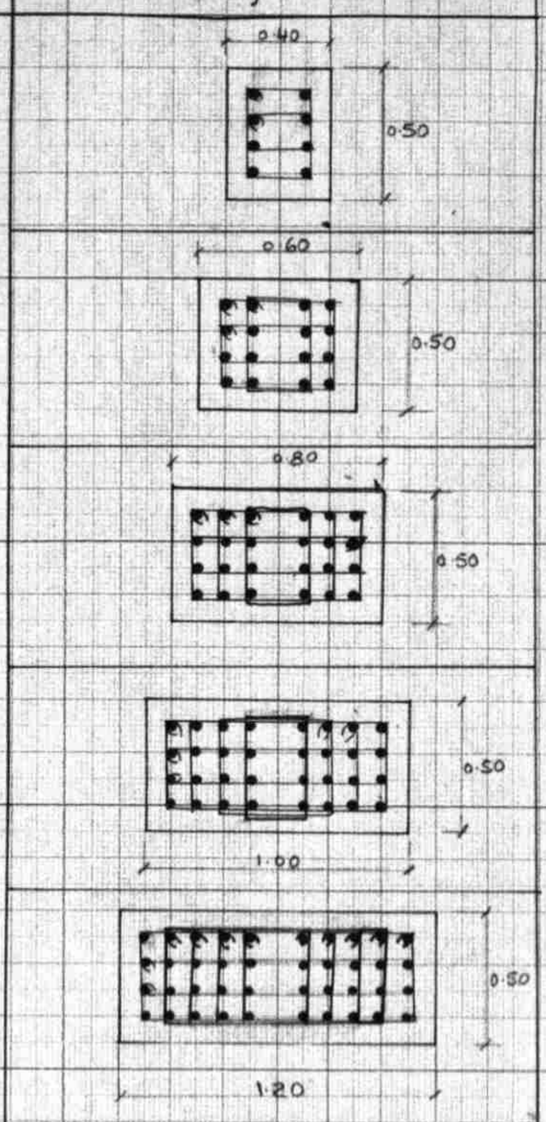
COMPUTER : RIAD SHAHIN	WIND ANALYSIS
CHK'D BY : RIAD SHAHIN	COLUMN AXIAL STRESSES
APP'D BY : Dr. JACK NASSER	DATE: DECEMBER 1964 — SHEET No 147/

Floor	M_1 (T-m)	M_2 (T-m)	M_1+M_2 (T-m)	$2(M_1+M_2)$ (T-m)	ΣPh (T-m)	$\Sigma Ph-2(M_1+M_2)$ (T-m)	F_1 T	0.435F T
20	0.53	0.86	1.39	2.78	6.28	3.50	0.20	0.10
19	1.80	2.48	4.28	8.56	25.20	16.64	0.94	0.41
18	2.93	4.00	6.93	13.86	56.40	42.54	2.40	1.04
17	4.55	5.41	9.96	19.92	99.70	79.78	4.50	1.95
16	4.30	6.52	10.82	21.64	155.30	133.66	7.50	3.25
15	5.36	8.02	13.38	26.76	222.60	195.84	11.00	4.78
14	6.31	9.27	15.58	31.16	302.20	271.04	15.30	6.62
13	8.10	10.80	18.90	37.80	392.10	364.30	20.60	8.90
12	6.46	9.83	16.29	32.58	493.50	460.93	26.00	11.30
11	7.80	11.50	19.30	38.60	606.50	567.90	32.00	13.90
10	8.35	15.78	24.13	48.26	727.90	679.64	38.30	16.80
9	10.35	16.10	26.45	52.90	863.90	811.00	45.80	19.90
8	7.90	14.47	22.37	44.74	1008.30	963.56	54.40	24.00
7	9.20	16.50	25.70	51.40	1161.20	1109.80	62.50	27.20
6	10.00	17.83	27.83	55.66	1324.80	1269.14	71.50	31.00
5	12.25	19.00	31.25	62.50	1496.40	1433.90	80.60	35.00
4	8.20	16.40	24.60	49.20	1678.20	1629.00	92.00	40.00
3	8.30	20.37	28.67	57.34	1867.00	1809.66	102.00	44.20
2	31.05	41.73	72.78	145.56	2065.50	1919.94	108.00	46.80
1	46.22	51.60	97.82	195.64	2279.20	2083.56	118.00	51.00

Column Designation (a)	Area m²	P: D.L (T)	P: Windload (T)	P_T (T)	M (T-m)	e (M/P)	Condition of Failure	Pg %	Reinforcement: As (cm²) Total	As Reqd /Row	As Furnished Ø	/Row cm²	a (m)	b (m)	c (m)	d (m)	e (m)
20a	0.50x0.40=0.20	94.70	0.10	94.80	1.96	< 1/3	Compression	1	20	10	4Ø18	10	0.10				
19a	"	118.40	0.41	118.81	3.53	"	"	2	40	20	2Ø28 + 2Ø25	24.40	"				
18a	"	142.10	1.04	143.14	5.32	"	"	4	80	40	2Ø40 + 2Ø32	40.40	"				
17a	"	165.80	1.95	167.75	6.38	"	"	5	100	50	4Ø40	48.80	"				
16a	0.50x0.60=0.30	198.35	3.25	193.60	9.37	"	"	3	90	22.50	4Ø28	24.40	0.10	0.20			
15a	"	214.90	4.78	219.68	10.76	"	"	4	120	30	4Ø32	32	"	"			
14a	"	239.45	6.62	246.07	12.34	"	"	5	150	37.5	2Ø40 + 2Ø30	38.80	"	"			
13a	"	264.00	8.90	272.90	12.97	"	"	5	150	37.50	2Ø40 + 2Ø30	38.80	"	"			
12a	0.50x0.80=0.40	289.40	11.30	300.70	15.63	"	"	3	120	20	2Ø28 + 2Ø25	22.20	0.10	0.20	0.30		
11a	"	314.80	13.90	328.70	17.39	"	"	4	160	26.60	2Ø32 + 2Ø30	30	"	"	"		
10a	"	340.20	16.80	357.00	18.98	"	"	5	200	33.30	2Ø40 + 2Ø25	34.26	"	"	"		
9a	"	365.60	19.90	385.50	17.84	"	"	5	200	33.30	2Ø40 + 2Ø25	34.26	"	"	"		
8a	0.50x1.00=0.50	391.85	24.00	414.85	22.66	"	"	4	200	25	4Ø28	24.40	0.10	0.20	0.30	0.40	—
7a	"	418.10	27.20	445.30	24.58	"	"	4	200	25	4Ø28	24.40	"	"	"	"	
6a	"	444.35	31.00	475.35	25.36	"	"	5	250	31.25	4Ø32	32	"	"	"	"	
5a	"	470.60	35.00	505.60	24.72	"	"	5	250	31.25	4Ø32	32	"	"	"	"	
4a	0.50x1.20=0.60	497.70	4 00	537.70	28.28	"	"	4	240	24	4Ø28	24.90	0.10	0.20	0.30	0.40	0.50
3a	"	520.80	44.20	569.00	33.24	"	"	5	300	30	4Ø32		"	"	"	"	"
2a	"	554.05	46.80	600.85	44.70	"	"	5	300	30	4Ø32	32	"	"	"	"	"
1a	"	582.80	51.00	633.80	52.50	"	"	6	360	36	2Ø40 + 2Ø32	40.40	"	"	"	"	"
20	0.50x0.40=0.20	16.10	0.20	16.30	1.33			1	20	10	4Ø18	10	0.10				
19	"	32.20	0.94	33.14	3.95	"	"	1	20	10	4Ø18	10	"				
18	"	48.30	2.40	50.70	5.17	"	"	1	20	10	4Ø18	10	"				
17	"	64.40	4.50	68.90	5.46	"	"	2	40	20	2Ø28 + 2Ø25	24.40	"				
16	0.50x0.60=0.30	81.35	7.50	88.85	6.95	"	"	2	60	15	4Ø22	13.52	0.10	0.20			
15	"	98.30	11.00	109.30	8.13	"	"	2	60	15	4Ø22	12.52	"	"			
14	"	115.25	15.30	130.55	9.28	"	"	2	60	15	4Ø22	13.52	"	"			
13	"	132.20	20.60	152.80	9.85	"	"	2	60	15	4Ø22	13.52	"	"			
12	0.50x0.80=0.40	150.00	26.00	176.00	11.25	"	"	2	80	13.30	4Ø22	13.52	0.10	0.20	0.30		
11	"	167.80	32.00	199.80	12.55	"	"	2	80	13.30	4Ø22	13.52	"	"	"		
10	"	185.60	38.30	223.90	13.20	"	"	2	80	13.30	4Ø22	15.32	"	"	"		
9	"	202.40	45.80	249.20	13.74	"	"	2	80	13.30	4Ø22	15.32	"	"	"		
8	0.50x1.00=0.50	222.05	54.00	276.45	15.68	"	"	2	100	12.50	4Ø20	12.60	0.10	0.20	0.30	0.40	
7	"	240.70	62.50	303.20	17.00	"	"	2	100	12.50	4Ø20	12.60	"	"	"	"	
6	"	259.35	71.50	330.85	17.40	"	"	2	100	12.50	4Ø20	12.60	"	"	"	"	
5	"	278.00	80.60	358.60	17.50	"	"	3	150	18.75	4Ø25	19.72	"	"	"	"	
4	0.50x1.20=0.60	297.50	92.00	389.50	19.47	"	"	2	120	12	4Ø20	12.64	0.10	0.20	0.30	0.40	
3	"	317.00	102.00	419.00	23.80	"	"	3	180	18	4Ø25	19.72	"	"	"	"	
2	"	33.865	108.00	446.65	33.57	"	"	3	180	18	4Ø25	19.72	"	"	"	"	
1	"	359.80	118.00	477.80	46.92	"	"	4	240	24	4Ø28	24.40	"	"	"	"	

Column Designation (a)	Moment of inertia of concrete section: d_3 (m²)	I_c (m⁴)	Moment of inertia of steel section (m⁴): $I_s = \frac{A_s}{10^4}(a^2+b^2+c^2+d^2+e^2)$	Total moment of inertia (m⁴) $I_t = I_c + (2n-1) I_s$: (2n−1)	(2n−1) Is (m⁴)	It (m⁴)	Fa (T/m²) $0.80(0.225 f'_c + f_s P_g)$	Fb (T/m²) $0.45 f'_c$	fa (T/m²) P/Ag	fb (T/m²) Mc/It	fa/Fa	fb/Fb	fa/Fa + fb/Fb
20a		0.00262	0.01/104 x10 = 0.00001	15	0.00015	0.00277	640	1180	472	1.96x0.20=142 / 0.0277	472/640 = 0.74	142/1180 = 0.12	0.86
19a		"	0.01/104 x24.40 = 0.0000224	"	0.00036	0.00298	808	"	592	3.53x0.20=245 / 0.00298	592/808 = 0.74	245/1180 = 0.21	0.95
18a		"	0.01/104 x40.40 = 0.0000404	"	0.000605	0.00323	1144	"	713	5.32x0.20=330 / 0.00323	713/1144 = 0.62	330/1180 = 0.28	0.90
17a		"	0.01/104 x48.80 = 0.000488	"	0.000732	0.003352	1310	"	835	6.38x0.20=362 / 0.003352	835/1310 = 0.64	362/1180 = 0.31	0.95
16a		0.00900	0.05/104 x24.40 = 0.0001220	"	0.000182	0.0108	976	"	640	9.37x0.30=260 / 0.0108	640/976 = 0.65	260/1180 = 0.22	0.87
15a		"	0.05/104 x32 = 0.000160	"	0.0024	0.0114	1144	"	730	10.76x0.30=282 / 0.0114	730/1144 = 0.64	282/1180 = 0.24	0.86
14a		"	0.05/104 x38.38 = 0.000194	"	0.0029	0.0119	1310	"	815	12.34x0.30=310 / 0.0119	815/1310 = 0.63	310/1180 = 0.26	0.89
13a		"	0.05/104 x38.80 = 0.000194	"	0.0029	0.0119	1310	"	903	12.97x0.30=327 / 0.0119	903/1310 = 0.69	327/1180 = 0.28	0.97
12a		0.0213	0.14/104 x22.20 = 0.00031	"	0.0047	0.0260	976	"	750	15.63x0.40=240 / 0.0260	750/976 = 0.77	240/1180 = 0.20	0.97
11a		"	0.14/104 x30 = 0.00042	"	0.0063	0.0276	1144	"	820	17.39x0.40=252 / 0.0276	820/1144 = 0.72	252/1180 = 0.21	0.93
10a		"	0.14/104 x34.26 = 0.00048	"	0.0072	0.0285	1310	"	890	18.98x0.40=267 / 0.0285	890/1310 = 0.68	267/1180 = 0.23	0.91
9a		"	0.14/104 x34.26 = 0.00048	"	0.0072	0.0285	1310	"	960	17.84x0.40=257 / 0.0285	960/1310 = 0.74	257/1180 = 0.21	0.95
8a		0.0416	0.30x24.40/104 = 0.00073	"	0.0110	0.0526	1144	"	828	22.66x0.50=217 / 0.0526	828/1144 = 0.72	217/1180 = 0.18	0.90
7a		"	0.30x24.40/104 = 0.00073	"	0.0110	0.0526	1144	"	890	24.58x0.50=233 / 0.0526	890/1144 = 0.78	233/1180 = 0.20	0.98
6a		"	0.30x32/104 = 0.00096	"	0.0144	0.0560	1310	"	950	25.36x0.50=222 / 0.056	950/1310 = 0.73	227/1180 = 0.19	0.92
5a		"	0.30x32/104 = 0.00096	"	0.0144	0.0560	1310	"	1010	24.72x0.50=220 / 0.0560	1010/1310 = 0.77	220/1180 = 0.18	0.95
4a		0.0720	0.55x24.40/104 = 0.00134	"	0.0200	0.092	1144	"	890	28.28x0.60=185 / 0.092	890/1144 = 0.78	185/1180 = 0.16	0.94
3a		"	0.55x32/104 = 0.00176	"	0.0264	0.0984	1310	"	945	33.24x0.60=203 / 0.0984	945/1310 = 0.72	203/1180 = 0.17	0.89
2a		"	0.55x32/104 = 0.00176	"	0.0264	0.0984	1310	"	1000	44.70x0.60=272 / 0.0984	1000/1310 = 0.76	272/1180 = 0.23	0.99
1a		"	0.55x40.40/104 = 0.0222	"	0.0333	0.1053	1480	"	1050	52.50x0.60=300 / 0.1053	1050/1480 = 0.71	300/1180 = 0.25	0.96
20		0.00262	0.01x10/104 = 0.00001	15	0.00015	0.0277	640	1180	8150	1.33x0.20=97 / 0.0277	81.50/640 = 0.13	97/1180 = 0.08	0.21
19		"	0.01x10/104 = 0.00001	"	0.00015	0.0277	640	"	165	3.95x0.20=280 / 0.0277	165/640 = 0.26	286/1180 = 0.20	0.50
18		"	0.01x10/104 = 0.00001	"	0.00015	0.0277	640	"	252	5.17x0.20=373 / 0.0277	252/640 = 0.40	373/1180 = 0.32	0.72
17		"	0.01x24.40/104 = 0.0000244	"	0.00036	0.00298	808	"	344	5.46x0.20=366 / 0.0298	344/808 = 0.43	366/1180 = 0.31	0.74
16		0.00900	0.05x13.52/104 = 0.000675	"	0.0010	0.0100	808	"	295	6.95x0.30=210 / 0.010	295/808 = 0.37	210/1180 = 0.18	0.55
15		"	0.05x13.52/104 = 0.000675	"	0.0010	0.0100	808	"	352	8.13x0.30=248 / 0.010	352/808 = 0.44	243/1180 = 0.21	0.65
14		"	0.05x13.52/104 = 0.000675	"	0.0010	0.0100	808	"	434	9.28x0.30=278 / 0.010	434/808 = 0.54	278/1180 = 0.24	0.78
13		"	0.05x13.52/104 = 0.000675	"	0.0010	0.0100	808	"	509	9.85x0.30=295 / 0.0100	509/808 = 0.63	295/1180 = 0.25	0.88
12		0.0213	0.14x15.32/104 = 0.000203	"	0.0032	0.0245	808	"	440	11.25x0.40=184 / 0.0245	440/808 = 0.55	184/1180 = 0.16	0.71
11		"	0.14x15.32/104 = 0.000203	"	0.0032	0.0245	808	"	500	12.55x0.40=200 / 0.0205	500/808 = 0.62	204/1180 = 0.17	0.79
10		"	0.14x15.32/104 = 0.000203	"	0.0032	0.0245	808	"	560	13.20x0.40=215 / 0.0243	560/808 = 0.69	215/1180 = 0.18	0.87
9		"	0.14x15.32/104 = 0.000203	"	0.0032	0.0245	808	"	622	13.74x0.40=224 / 0.0245	622/808 = 0.77	224/1180 = 0.19	0.96
8		0.0416	0.30x12.64/104 = 0.00038	"	0.0057	0.0473	808	"	552	15.68x0.50=165 / 0.0473	552/808 = 0.69	165/1180 = 0.14	0.83
7		"	0.30x12.64/104 = 0.00038	"	0.0057	0.0473	808	"	605	17.00x0.50=180 / 0.0493	605/808 = 0.75	180/1180 = 0.15	0.90
6		"	0.30x12.64/104 = 0.00038	"	0.0057	0.0473	808	"	660	17.40x0.50=184 / 0.0473	660/808 = 0.80	180/1180 = 0.16	0.96
5		"	0.30x19.72/104 = 0.00059	"	0.0088	0.504	976	"	715	17.50x0.50=173 / 0.504	715/976 = 0.73	173/1180 = 0.15	0.88
4		0.0720	0.55x12.60/104 = 0.00070	"	0.0105	0.825	808	"	650	19.47x0.60=142 / 0.825	650/808 = 0.80	142/1180 = 0.12	0.92
3		"	0.55x19.72/104 = 0.00108	"	0.0162	0.0882	976	"	700	23.80x0.60=162 / 0.0882	700/976 = 0.73	162/1180 = 0.14	0.87
2		"	0.55x19.72/104 = 0.00108	"	0.0162	0.0882	976	"	742	33.57x0.60=242 / 0.0882	742/976 = 0.76	242/1180 = 0.21	0.97
1		"	0.55x24.40/104 = 0.00134	"	0.0200	0.092	1144	"	792	46.92x0.60=307 / 0.092	792/1144 = 0.69	307/1180 = 0.26	0.95

Sections Showing Reinforcement



Sections as above

ANALYSIS OF THE EFFECT OF WIND ON A HIGH REINFORCED CONCRETE BUILDING

Comparison of Approximate and Exact Methods

COMPUTER: RIAD SHAHIN	REINFORCEMENT IN COLUMNS
CHK'D BY: RIAD SHAHIN	
APP'D BY: Dr. JACK NASSER	DATE DECEMBER 1984 SHEET No. 149

PART D

CRITICAL FRAME FOOTINGS

Interior Footing:

1. Concrete and Steel Data

$f'_c = 263 \text{ Kg/cm}^2$

$fc = 118 \text{ Kg/cm}^2$

$fs = 2100 \text{ Kg/cm}^2$

$v = 0.03 \times 263 = 7.90 \text{ Kg/cm}^2$

$u = 0.08 \times 263 = 21.00 \text{ Kg/cm}^2$

2. Proportioning

$P = 633.80 \text{ T}$

$M = 52.50 \text{ T-m}$

$\text{Bearing Capacity} = 300 \text{ T/m}^2$

$\text{D.L.} = 0.06 \times 633.80 = 38.20 \text{ T}$

$P_{total} = 633.80 + 38.20 = 672.00 \text{ T}$

$A = \frac{672}{300} = 2.25 \text{ m}^2$

Use 1 x 2.25 m

$q_n = \frac{633.80}{2.25} = 282 \text{ T/m}^2$

$s = \frac{2.25}{1} = 2.25$

$B' = B\sqrt{2s - 1} = 1.00 \sqrt{4.50-1} = 1\sqrt{3.50} = 1.86 \text{ m}$

$$\frac{a}{B'} = \frac{0.50}{1.86} = 0.27$$

Use Eq. 19.2[1]

$$\frac{d}{B'} = \frac{\sqrt{2\,C + 4\,C^2 + \frac{K^2}{4}} - \frac{K}{2}\,(1+4C)}{2 + 4C}$$

The constant C is evaluated from the net soil pressure q_n (lb/sq.ft) and allowable diagonal tension v (lb/sq.in) by the expression

$$C = \frac{q_n}{500v}$$

$$q_n = 28.20 \text{ Kg/cm}^2 = \frac{28.20}{0.07} = 403 \text{ psi} = 403 \times \overline{12}^2 = 58{,}000 \text{ lb/ft}^2$$

$$v = \frac{7.90}{0.07} = 113 \text{ psi}$$

$$C = \frac{58{,}000}{500 \times 113} = 1.03$$

$$K = \frac{a}{B'} = 0.27$$

$$\frac{d}{B'} = \frac{\sqrt{2.06 + 4 \times 1.07 + 0.073/4} - 0.135(1+4.12)}{2 + 4.12}$$

$$= \frac{\sqrt{2.06 + 4.28 + 0.018} - 0.135(5.12)}{6.12}$$

$$= \frac{\sqrt{6.36} - 0.69}{6.12} = \frac{2.52 - 0.69}{6.12}$$

$$= \frac{1.83}{6.12} = 0.30$$

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(1) Peck, Hanson and Thornburn, "Foundation Engineering", P. 315, John Wiley & Sons, Inc. New York, 1953.

$d = 0.30 \times 1.86 = 56$ cms   say 80 cms.

$kd = 0.312 \times 0.80 = 0.25$ m

$jd = 0.896 \times 0.80 = 0.72$ m

3. Net Soil Pressures

$e = \frac{M}{P} = \frac{52.50}{672} = 0.078 < \frac{2.25}{6}$ so resultant in mid 1/3

$$q = \frac{\Sigma V}{BL} \left(1 \mp \frac{6e}{l}\right)$$

$$= \frac{672}{2.25} \left(1 \mp 6 \times \frac{0.078}{2.25}\right)$$

$$= 300 (1 \mp 0.21) = 365 \ T/m^2 = q_{max}$$

$$= 237 \ T/m^2 = q_{min}$$

4. Check Diagonal Tension at de

The critical sections for shear is commonly located at a distance d from the face of the column, which falls outside the footing. This means that the footing is quite safe for shear.

However, the 1963 edition of the A.C.I. Code permits the location of the critical section at a distance of d/2. Checking the shear at this section we have:

Average pressure on efgh $= \frac{360 + 365}{2} (1.00 \times 0.125)$

$$= 362.50 \times 0.125 = 40.20 \ T = V$$

$$v = \frac{V}{bod} = \frac{40.20}{1.00 \times 0.80} = \frac{40.20}{0.80} = 50.20 \ T/m^2 < 79 \ T/m^2$$

$\therefore$ O.K.

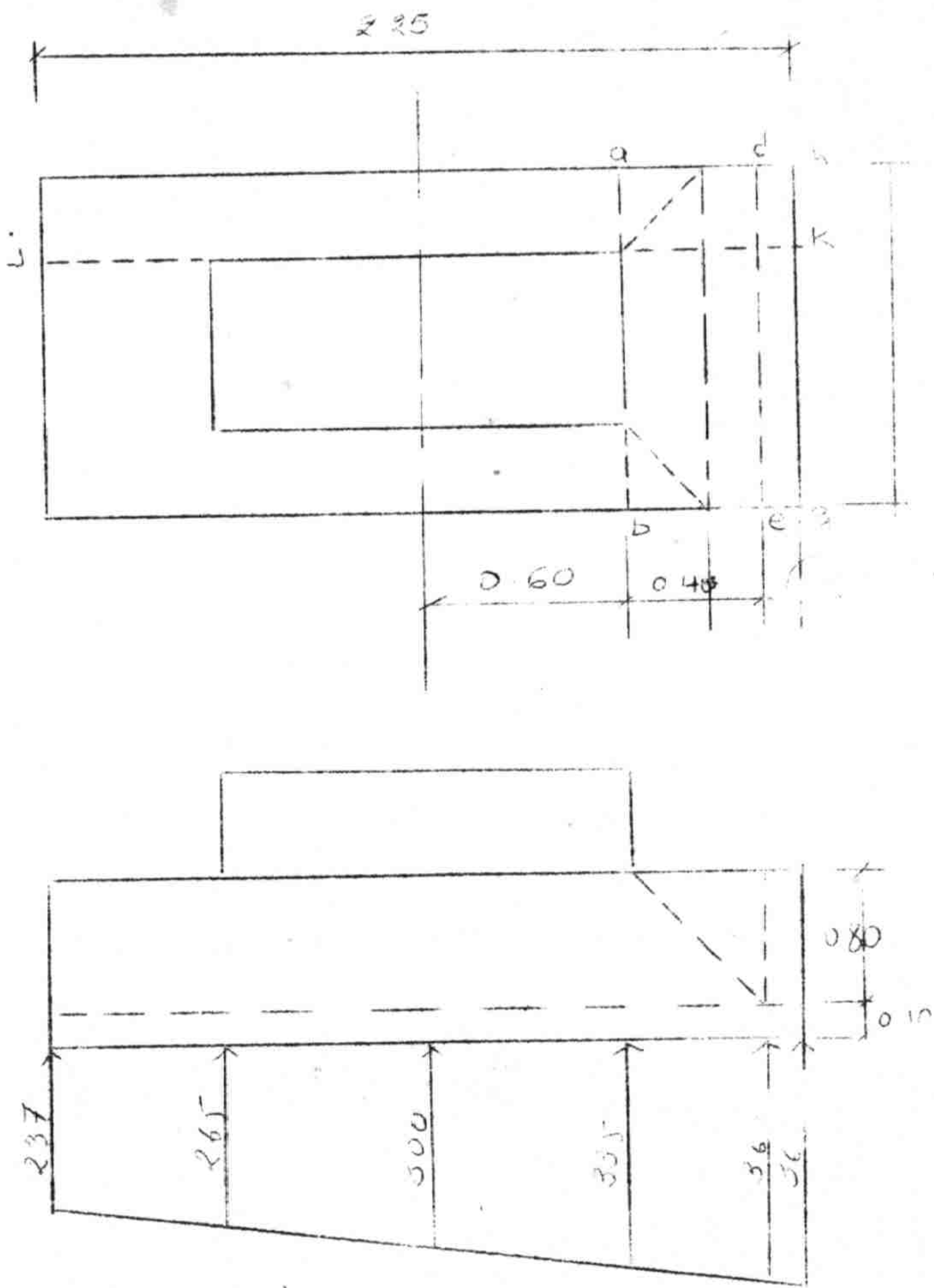

Fig 1

5. Check Concrete at ab

Use two triangular pressure variations for convenience.

$\frac{365}{2}$ (0.40 x 1.00) = 73 T

x 2/3 (0.40) = 19.50 T-m

$\frac{335}{2}$ (0.40 x 1.00) = 67 T

x 1/3 x 0.40 = $\underline{8.90}$ T-m

28.40 T-m

V = $\overline{140}$ T

Total Compression = $\frac{28.40}{0.72}$ = 39.50 T

$\therefore \div (\frac{1.00x0.25}{2})$ = 315 T/m^2

$<$ 1180 T/m^2

6. Steel Required at ab

As = $\frac{39.50}{2100}$ m^2 = 188 m^2

Use 24 ø 32

As (furnished) = 192 cm^2

Σo (furnished) = 240 cms

v = $\frac{140}{2.40x0.72}$ = 81 T/m^2

$<$ 210 T/m^2

7. Steel Required at jK

Since the moment may act in either direction, use average pressure from ℄ to K over entire area.

$$\text{Average pressure} = \frac{300 + 365}{2} = 332.50 \ T/m^2$$

$$V = 332.50\ (0.25 \times 2.25) = 187\ T$$

$$\times\ 0.125 = 24.30\ T\text{-}m = M$$

$$As = \frac{24.30}{2100 \times 0.72} \times 10^4 = 160\ cm^2$$

Use 20 ø 32 mm

$$As\ (\text{furnished}) = 160\ cm^2$$

$$o\ (\text{furnished}) = 200\ cms$$

$$U = \frac{187}{2.00 \times 0.72} = 130\ T/m^2 < 210\ T/m^2$$

Use 24 ø 32 long way) Uniform spacing
Use 20 ø 32 short way)

N.B. Since the size of the most critical footing is relatively small, it is recommended to maintain the same size for other footings.