TABLE 3.4--CALCULATED AND MEASURED DUCTILITY FACTORS

(The values of ultimate compressive strain adopted in the calculation are shown in table.3.3)

Beam no.	Ductility Factor (calculated)	Ductility factor (measured)
4	3. 02	3
5	4. 29	5
6	5. 47	5
7	5. 93	6
8	4. 66	6
9	4. 63	5

TABLE 3.5--CALCULATED AND MEASURED DUCTILITY FACTORS

(The values of ultimate compressive strain adopted in the calculation are assumed to be 0.33%)

Beam no.	Ductility Factor (calculated)	Ductility factor (measured)
4	3. 02	3
5	2. 83	5
6	2. 81	5
7	2. 78	6
8	2. 78	6
9	2. 77	5

TABLE 3.6--MEASURED AND CALCULATED YIELD STRENGTH LOADS AND ULTIMATE STRENGTH LOADS

(The values of ultimate compressive strain adopted in the calculation are shown in table.3.3)

Beam no.	Yield strength load(kN)		Ultimate strength load(kN)	
	Measured	Calculated	Measured	Calculated
4	37. 6	36. 9	38. 5	39. 4
5	42. 5	39. 2	45. 4	41. 7
6	44. 1	39. 6	49. 3	43. 3
7	44. 3	40. 0	49. 6	44. 3
8	42. 2	40. 0	44. 9	42. 6
9	42. 7	40. 2	43. 5	42. 6

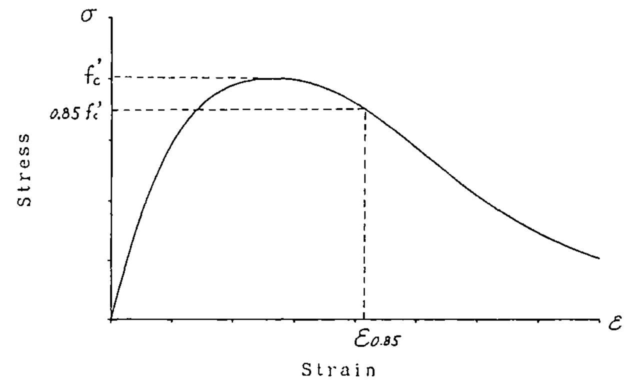

Fig. 2.1--Definition of $\epsilon_{0.85}$ of fiber mixed concrete

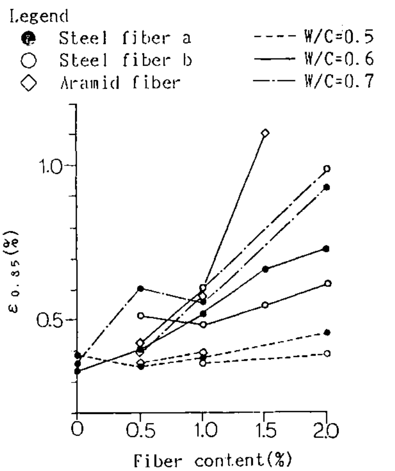

Fig. 2.2--Ultimate compressive strain ($\epsilon_{0.85}$) of fiber mixed concrete

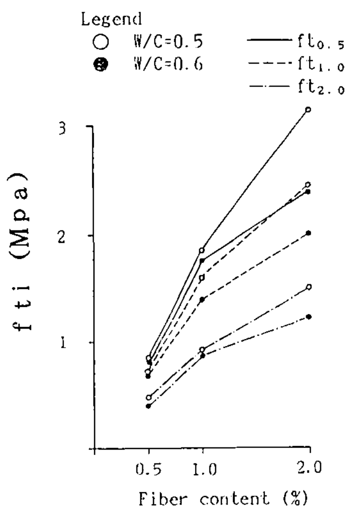

Fig. 2.5--Approximate tensile strength of fiber mixed concrete

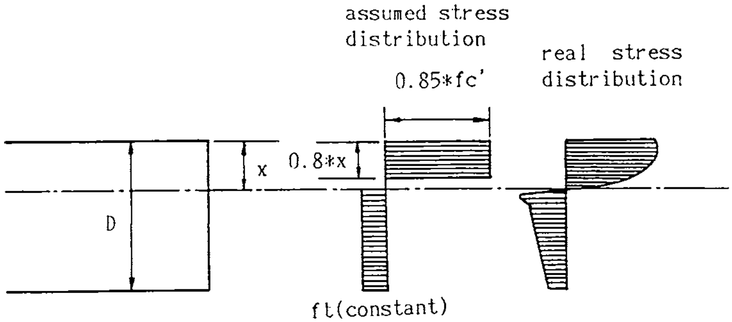

Fig. 2.3--Stress distribution of the cross section of fiber mixed concrete specimens in the flexural test

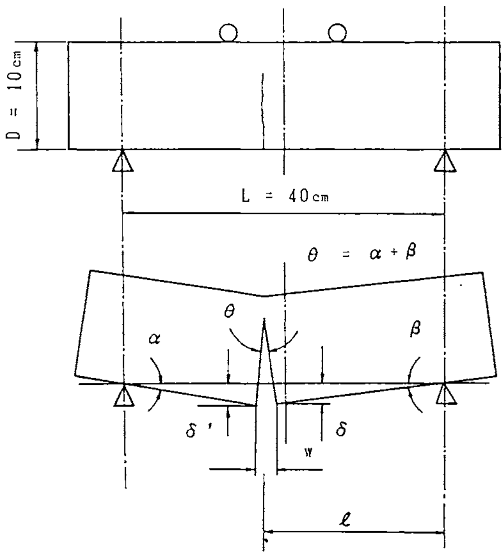

Fig. 2.4--Deformation model of fiber mixed concrete specimens in bending

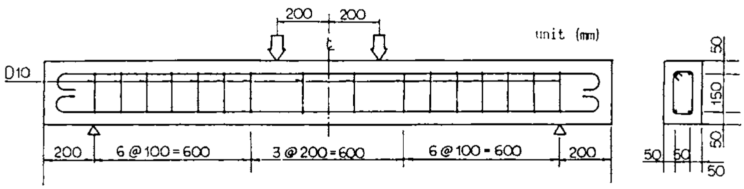

Fig. 3.1--Dimension of beam specimens

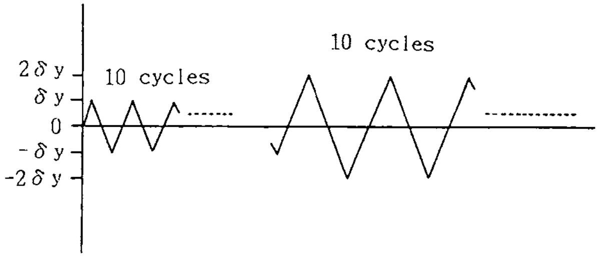

Fig. 3.2--Cyclic loading program

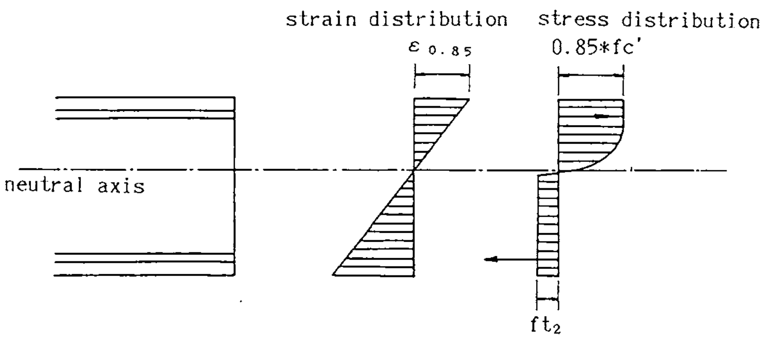

Fig. 3.4--Assumed distribution in the cross section of fiber mixed reinforced concrete beam (ultimate state)

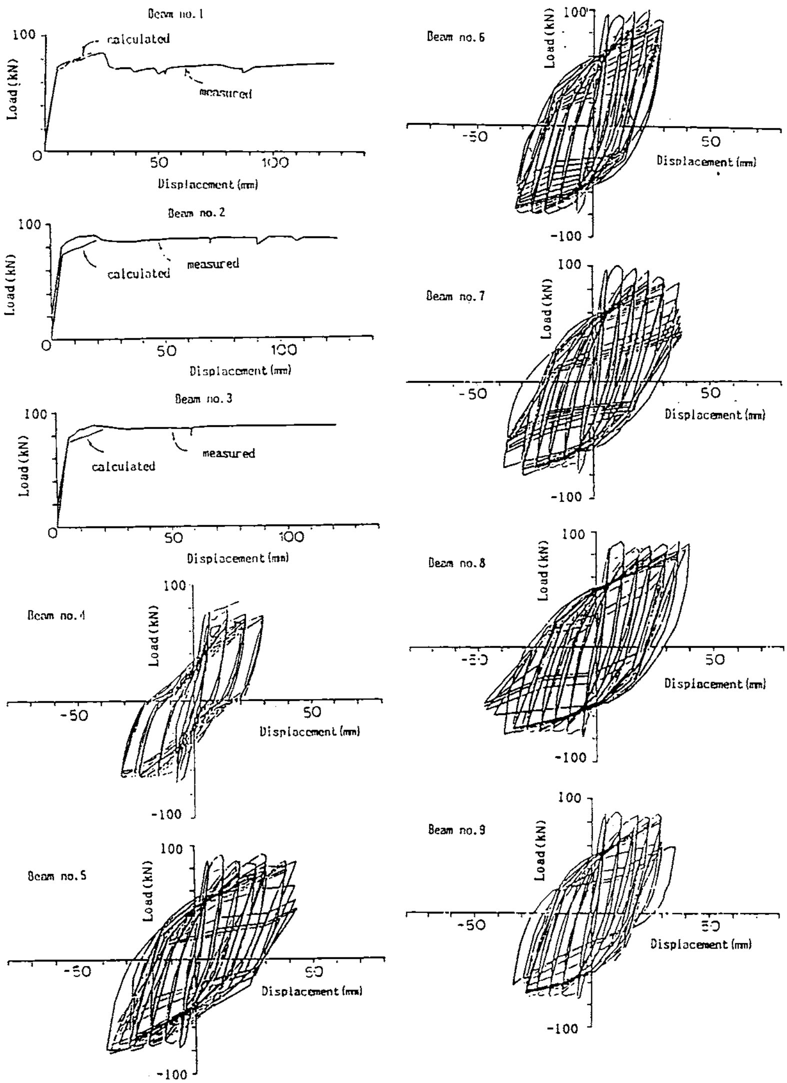

Fig. 3.3--Load-displacement curves of beams

SP 128-60

Interference Effect on Wind Loads on Tall Buildings

by A. K. Ahuja, S. K. Pathak, and S. A. Mir

Synopsis: The wind tunnel tests were carried out on rigid models of tall buildings with square plan shape in order to study the effects of interference on wind loads on tall buildings. This paper presents the results of the same. Effects of various geometric and flow parameters on total force and moments are reported which are deduced from the wind pressure values obtained on isolated instrumented building models as well as instrumented buildings with interfering buildings in the near vicinity.

Keywords: High-rise buildings; measurement; models; moments; wind pressure

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INTRODUCTION

Tall buildings, being slender in form, are sensitive to wind. Evaluation of design wind loads on buildings or structures requires information on design wind speed and pressure or force coefficients, which can be obtained from the relevant codes of practice or literature, to the extent it is available. Wind pressure or force coefficients thus obtained are generally based on wind tunnel tests of the models of isolated buildings or structures. However, wind forces get modified by the presence of nearby structures which can produce beneficial shielding or adverse increase in loading. An isolated building will be subjected to wind loads which are very different to those when the same is placed in a group of tall buildings.

The wind interference effects caused due to grouping of buildings or structures depend upon many parameters, such as distance between structures, their heights, relative positions and wind characteristics. Effect of interference on wind loads on circular, square or rectangular plan shaped tall and short building blocks have been studied by certain researchers by carrying out experiments in wind tunnels. Some of the known works are those by Bailey and Kwok (1), Blessman and Riera (2,3), Harris (4), Kareem (5), Reinhold, Tielman and Maher (6), Ruscheweyh (7), Scruton and Newberry (8) and Vickery (9). Although there exists a score of research publications on the subject of wind interference effects between two prismatic buildings, the available information is not yet enough to evolve a comprehensive recommendations for the designers. The present paper describes the work carried out by the authors in this direction to further add to the available information.

EXPERIMENTAL PROGRAMME

Models

The models of prismatic buildings are made from 6 mm thick perspex sheet. Two models are of size 50 x 50 x 400 mm (i.e. with height to base ratio of 8) and two are of size 60 x 60 x 120 mm (i.e. with height to base ratio of 2). Out of the four models, two (one from each set) are provided with pressure tappings for wind pressure measurements. Fifteen pressure points are provided on each vertical surface in three columns and five rows. In all sixty pressure points are provided on each model (Fig. 1). Plastic tubes from the pressure points are taken out from the base of the model so as to connect them to the transducer for measurement of pressures.

Flow Characteristics

The experiments are carried out in a boundary layer wind tunnel with a test section of 15 m length and 2 m x 2 m cross-section, under a free stream velocity of 15 m/sec. The velocity distribution at the test section follows the power-law distribution with the index of 1/7.5 which represents an open country terrain condition. The depth of the boundary layer is about 1 m. The turbulence intensity of the flow is about 16% near the flow and about 10% in the mid stream (Fig. 2).

Procedure of Measurement

Isolated instrumented models -- Both instrumented building models with height to base ratio (H/a) 2 and 8 are tested isolated for six wind directions (β) namely 0°, 15°, 30°, 45°, 60° and 75°. Wind pressure at all measuring points on all four vertical surfaces of each model are obtained with the help of pressure transducer.

Instrumented models along with interfering models -- Wind pressure values on instrumented building models are also obtained by keeping interfering models of same shape and size in the near vicinity (Fig. 3). The effect of wind incidence angle (β) on wind loads is studied on both sets of models, whereas, the effects of other parameters namely centre-to-centre radial distance between models (r), angle defining relative position (α), and relative inclination of models (Ψ) are studied on models with height to base ratio (H/a) 8 only.

RESULTS AND DISCUSSIONS

Wind forces acting on all four vertical surfaces of instrumented building models are calculated from the measured values of wind pressures on each surface. The resultant force in x and y directions are obtained by algebraic sum of forces on two faces in each direction. Similarly the overturning moments about the two horizontal axes and the torsional moment about the vertical axis are also evaluated from forces. The results are presented in the form of non-dimentional coefficients for forces and moments as defined below.

$$C_x = F_x/q\,A; \qquad C_y = F_y/q\,A; \qquad C = \sqrt{C_x^2 + C_y^2}$$

$$C_{M_x} = M_x/q\,Aa; \qquad C_{M_y} = M_y/q\,Aa; \qquad C_{M_t} = M_t/q\,Aa$$

where,

F_x, F_y = total wind force in x and y direction respectively

M_x, M_y = total overtuning moment about x and y axis respectively

M_t = total torsional moment about z axis

q = $\frac{1}{2}\,\rho\,V^2$

ρ = mass density of air

V = free stream velocity of wind

A = area of the building face (= a x H)

a = width of the building

H = height of the building

C_x, C_y = force coefficient in x and y direction respectively

C = resultant force coefficient

C_{M_x}, C_{M_y} = coefficient for overturning moment about x and y axis respectively

C_{M_t} = coefficient for torsional moment about z axis.

Effect of Wind Incidence Angle (β)

Isolated instrumented models -- Variation of force and moment coefficients on isolated building models due to variation in wind incidence angle (β) can be seen in Tables 1 and 2. Figs. 4 and 5 show variation of C_x and C_y with β, respectively. It is seen from these tables and figures that value of force coefficient in x-direction, C_x, decreases with increase in β from 0° to 75°. Rate of fall in values is more in case of model with height to base ratio 8 compared to that with height to base ratio 2. Its value is maximum when wind blows normal to one of the faces. At β = 75°, the direction of force even get changed. Force coefficient in y-direction, C_y, is not much affected by β for its value between 0° and 25°, but later it increases with β. Its value is maximum at β = 75°. However the resultant force coefficient C is not much affected by β.

Variation of C_{M_x} can be compared with that of C_y.

Similarly, variation of C_{M_y} is identical to that of C_x.

Torsional moment coefficient C_{M_t} is not much affected by β.

Instrumented models along with interfering models -- In case of models with H/a = 8, interfering building is kept once on upstream side (α = 22.5°) and once on downstream side (α = 157.5°). However models with H/a = 2 are tested for α = 22.5° only. Values of coefficients obtained are listed in Tables 3 to 5. It is observed that value of C_x increases as β increases from 0° to 15°, but it decreases subsequently when the interfering building is on the upstream side (α = 22.5°). Further, its value is less than that of isolated building as the instrumented building is in the wake of interfering building. However, when the interfering building is on the downstream side (α = 157.5°), variation of C_x with β is not much different from that of isolated case.

Effect of β on C_y is to increase C_y as β increases. Torsional moment coefficient C_{M_t} decreases