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Effect of Connecting Bridge on Axial Force in Corner columns of Structurally Coupled Tubular Buildings

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Abstract: Present paper describes the effect of connecting bridge on axial force in corner columns of structurally coupled tall buildings. To study the effect of structural coupling on the structural response of two high rise buildings, linear static analysis is carried out using STAAD PRO software. The structural system adopted for the building is tube in tube, each of the two buildings is square in plan with dimension as 30mX30mX180m. The wind loads considered for the analysis are obtained from experimental tests conducted in (Boundary Layer Wind Tunnel BLWT). The two buildings are connected by one skybridge / two skybridges, with dimension of each skybridge as 30mX6mX3m. The bridge is located at different levels. Due to presence of connecting bridge the structural response is modified. The results of these studies are presented in the present paper. It is observed that the connecting bridge does not have much effect on the axial force in columns.

Keywords*:* Tall Building; Structural Coupling; Sky Bridge**;** Tube in tube

I. INTRODUCTION

Due to limited land availability and population explosion, the present trend is towards high rise buildings. As normally high rise buildings are not constructed in isolation but in clusters. Sometimes two closely spaced tall buildings are, structurally coupled through bridges at different levels for functional reasons. Due to presence of connecting bridge the structural response and the internal forces induced in the structures are modified. Scant information regarding the effects on induced internal forces on structurally coupled tall buildings is available. However, for economical design of such structures the estimation of internal forces is a must. The buildings have been analysed when wind blows at 0°, 15°, 30°, 45°, 60°, 75° and 90°.

II. PREVIOUS RELATED WORK

There are several building systems which are used for tall buildings namely Flat Slab system, Flat Slab with Shear Wall system, Flat Slab with Shear Wall and Column system, Rigid frame system, Shear Wall frame system, Tubular structure etc. Normally for buildings with more than 50 storeys tubular structures are recommended. However, there is problem of 'shear lag' in this system. To overcome problem of shear lag tube in tube structures are used. Normally tall buildings are not constructed in isolation. Therefore from functional point of view these tall buildings which are constructed in clusters are joined by skybridge(s). The structural behaviour of connected buildings will get altered due provision of sky bridge. The present paper deals with effect on axial force of corner columns due to connection by provided by sky bridge.

III. DESCRIPTION OF THE BUILDING

For the present study 50 storeyed concrete tube in tube structure is selected. The outer tube consists of 10 spans of 3.0m each on all the four sides. The inner tube has 4 spans of 3.0m each on all the four sides. The outer and the inner tubes are connected with girders supporting the floors. The storey height is kept as 3.6 m and total height of building is 180m. The outer tube and inner tube both are square in plan with dimensions of outer tube as 30m x 30m and that of inner tube as 12m x 12m square. The building is provided with belt trusses at level 1, 13, 25, and 37 of the outer peripheral tube. The belt truss consists of diagonal members of the same size as spandrel beams. The cross braces at level 1, 13, 25 and 37 connecting the inner and outer tube are in addition to the floor girders. The size of the cross braces and spandrel beams are kept same. The relevant details are shown in Figs. 1 to 4.

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The supports are numbered from 1 to 56 for building 1 while for building 2 they are numbered from 3001 to 3056 at the corresponding locations. The columns on level 1of building 1 are numbered from 10101 to 10156, at level 2 from 10201 to 10256, and similarly for other floors. The columns on level 1 of building 2 are numbered from 50101 to 50156, at level 2 from 50201 to 50256, and similarly for other floors. Thus the column numbers of the two buildings differ by 40000 at corresponding locations.

The size of the four corner columns for the outer tube and inner tube are taken as under:

Level 1 – 12	1.50 m x 1.50 m
Level 13 – 24	1.35 m x 1.35 m
Level 25 – 36	1.20 m x 1.20 m
Level 37 – 50	0.90 m x 0.90 m

The column size for the inner columns of outer peripheral tube and the inner tube are as below:

Level 1 – 12	0.60 m x 1.50 m
Level 13 – 24	0.45 m x 1.35 m
Level 25 – 36	0.45 m x 1.20 m
Level 37 – 50	0.30 m x 0.90 m

Deep spandrel beams are provided along the periphery of the inner and the outer tube so that the web and flange behave more or less like a solid shear wall with window opening punctured in it. The sizes of the spandrel beams are as under:

Level 1 – 12	0.60 m x 1.65 m
Level 13 – 24	0.45 m x 1.65 m
Level 25 – 36	0.30 m x 1.50 m
Level 37 – 50	0.30 m x 1.05 m

The spandrel beams are numbered as 101 to 156 at level 1, 201 to 256 at level 2 and so on. The beams on level 1 of building 2 are numbered from 40101 to 40156, at level 2 from 40201 to 40256, and similarly for other floors. Thus the beam numbers of the two buildings differ by 40000 at corresponding locations.

The internal beams on all the floors are taken of size 0.45 m X 0.75 m, which are suitable to carry the floor loads coming upon it due to the dead loads and 100% live loads.

The connecting internal beams are numbered as 157 to 164 at level 1 and 257 to 264 at level 2 and so on in building 1. The belt truss and cross braces are provided in the buildings in order to reduce the displacements. The size of cross braces and the belt truss at a particular level are as under:

Level 1	0.60 m X 1.65 m
Level 13	0.45 m X 1.65 m
Level 25	0.30 m X 1.50 m
Level 37	0.30 m X 1.05 m

The material used in the present study is reinforced concrete. The concrete and the steel are M20 and Fe415 respectively.

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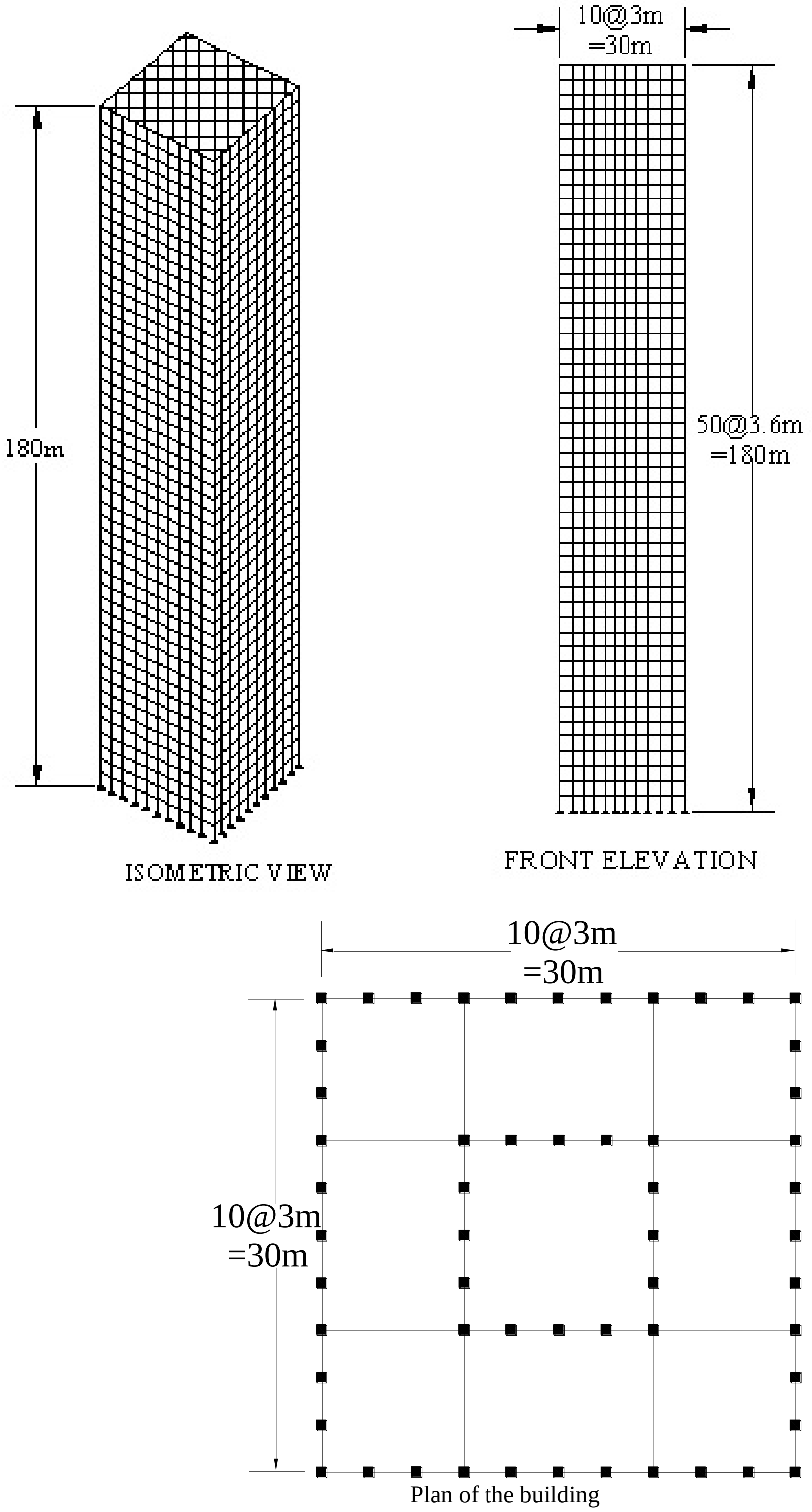

Fig. 1 Details of the building

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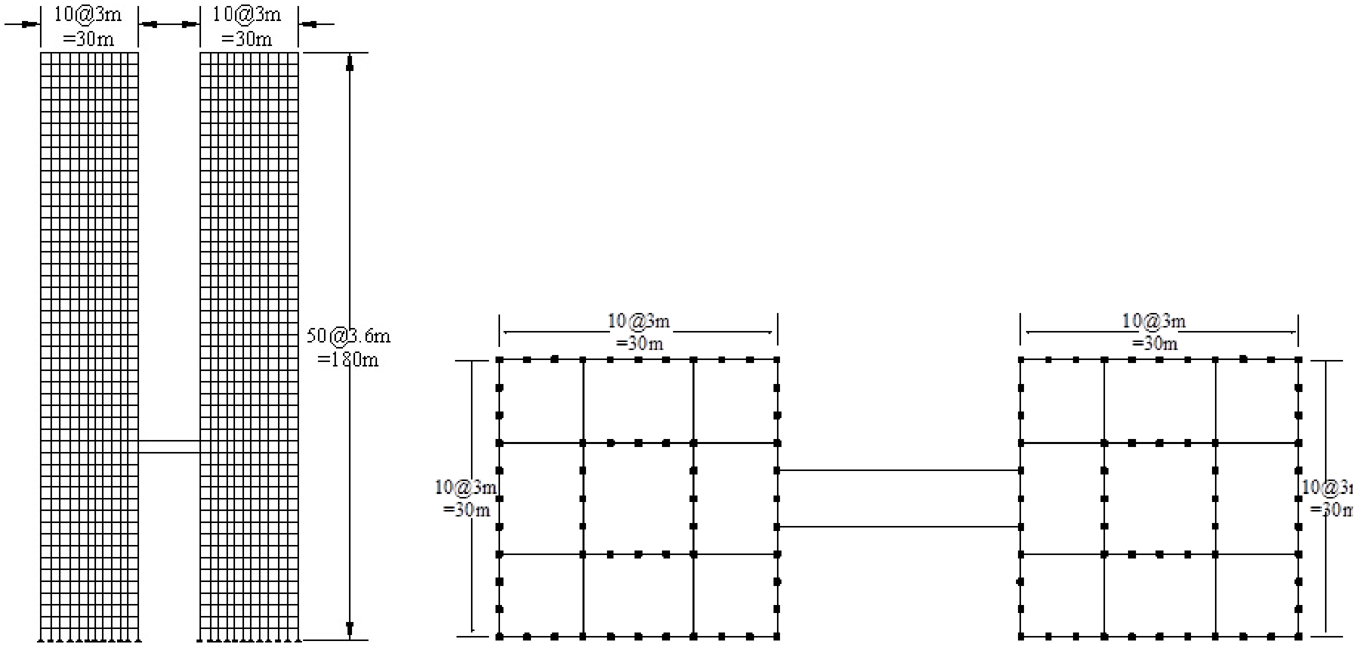

Two buildings connected by single skybridge

Plan of two connected buildings

Fig.2 Details of connected buildings

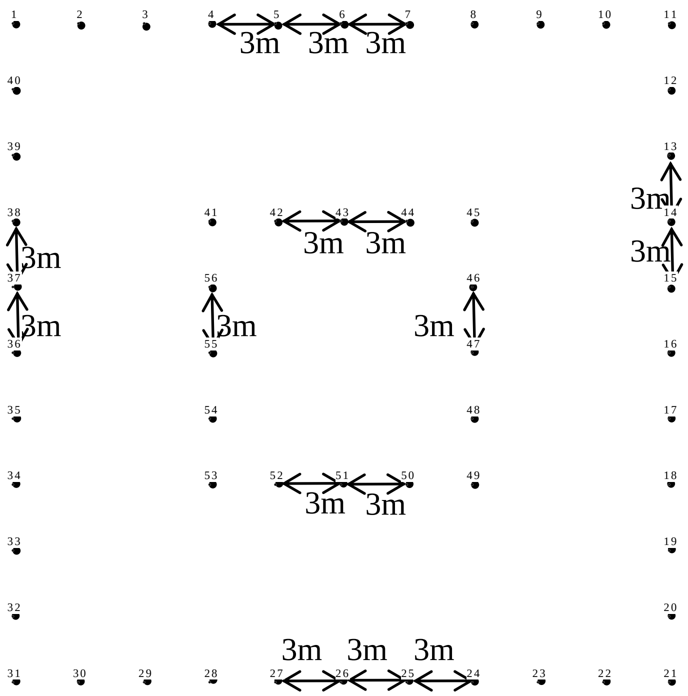

Fig. 3 Plan at ground level showing position of nodes for building 1

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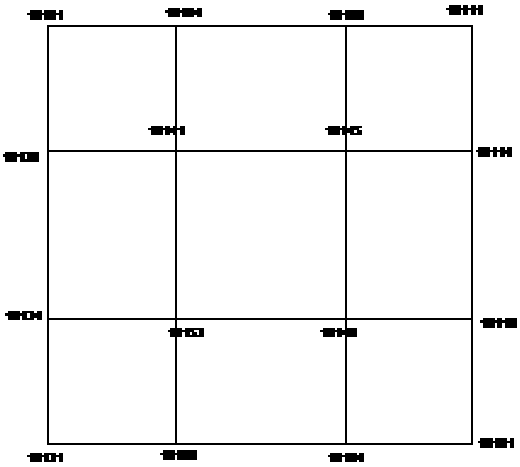

Fig. 4 Plan showing column numbers at level 1 for building 1

IV. RESULTS AND DISCUSSION

The results obtained from analysis are presented graphically for corner columns for isolated, unconnected case and for typical connected case for various wind incidence angles (Fig. 5 to Fig. 9) as below. Fig 10 and Fig. 11 depict the effect of bridge located at different levels for column 10101 for 0° and 90° angles. (Similar Figures for columns i.e. columns 10121, 50101 and 50121 are not presented here due to paucity of space). From the present study it is observed in column 50121, which is on the windward side and at non opposing face, there is an increase in axial force at 0° angle, of about 8% at lower levels and 4% at higher levels. However, in column located at opposing face (10121), there is decrease in axial force by 2%. In column 50101 (i.e. column on leeward side and at opposing face), there is increase of about 1% only. Similarly in column 10101 (i.e. column on leeward side and at non opposing face), there is increase in axial force of about 2%.

In leading building column on windward side (i.e. column 50121), there is increase in axial force of about 4% at 90° angle, whereas on leeward column of leading building (i.e. column 50101), there is decrease of about 1%. In trailing building (i.e. building-1) on column at the opposing edge (i.e. column 10121), there is increase of about 1%. But on column 10101 (i.e. on non opposing face), there is almost no effect. The axial force in all the columns changes abruptly in the vicinity of belt truss, and hence showing kinks in the figures. Typical figure for axial force for bridge located at 8th level is presented.

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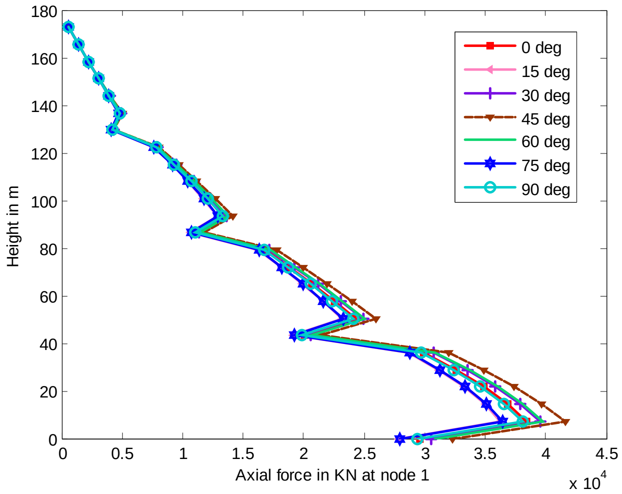

Fig.5 Variation of axial force in corner columns with height at column 10101(at node 1) for isolated case for various wind incidence angles.

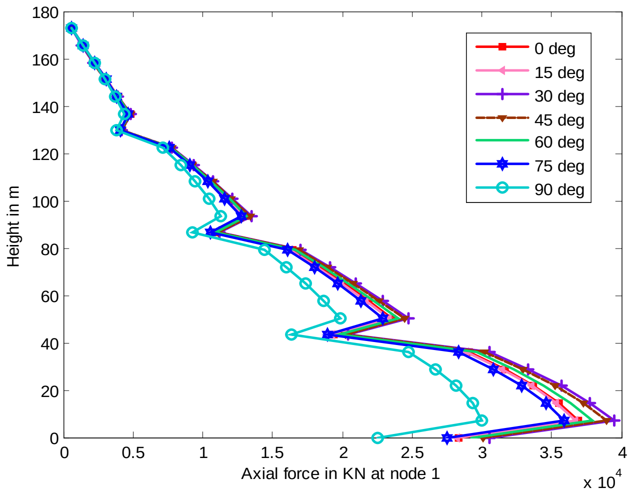

Fig.6 Variation of axial force in corner columns with height at column 10101(at node 1 Building 1) with height for unconnected case for various wind incidence angles.

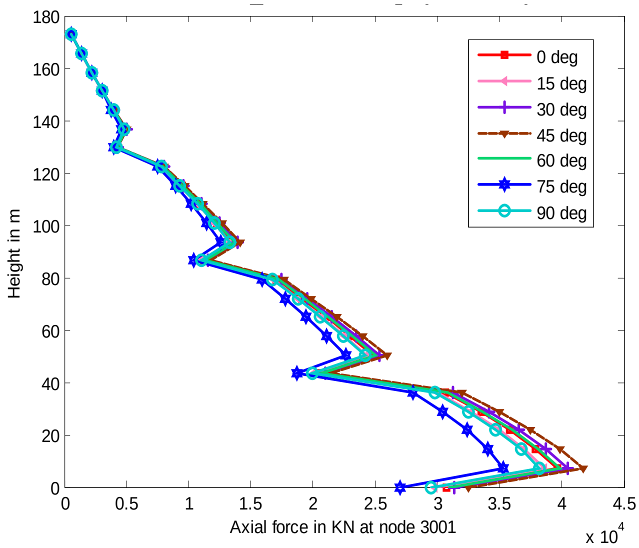

Fig. 7 Variation of axial force in corner columns with height at column 50101(at node 3001 Building 2) with height for unconnected case for various wind incidence angles.

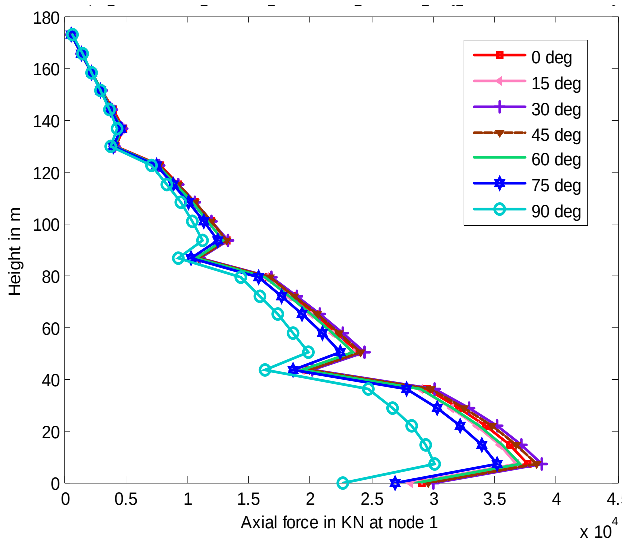

Fig. 8 Variation of axial force in corner columns with height column 10101(at node 1 connected Building 1) for case of single bridge located at 8th level for various wind incidence levels.

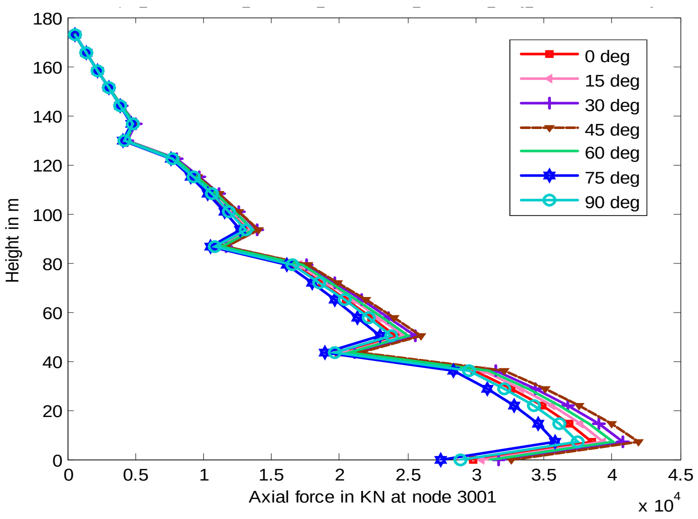

Fig. 9 Variation of axial force in corner columns with height column 50101(at node 3001 Building 2) for connected case of single bridge located at 8th level for various wind incidence angles

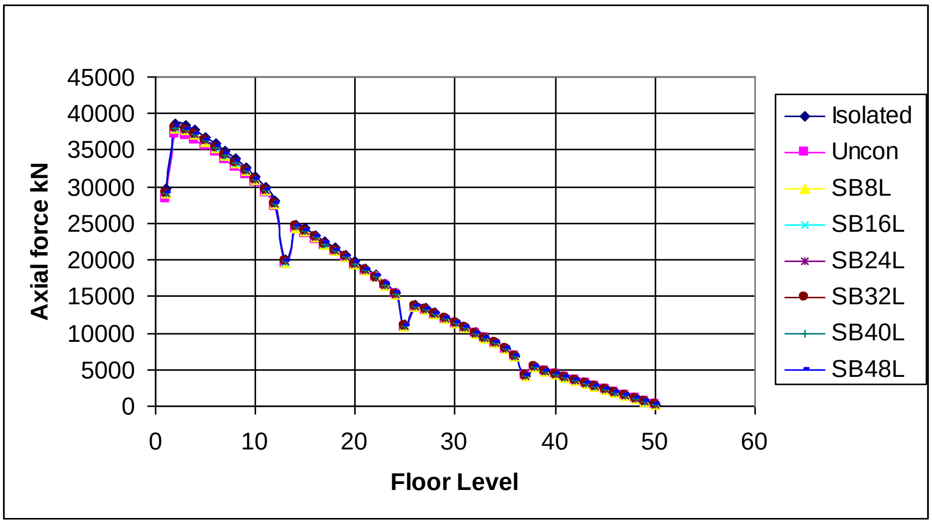

Fig. 10 Comparison of axial force in corner columns with floor levels at column10101 (at node 1 Building 1) for different cases at 0° wind incidence angle

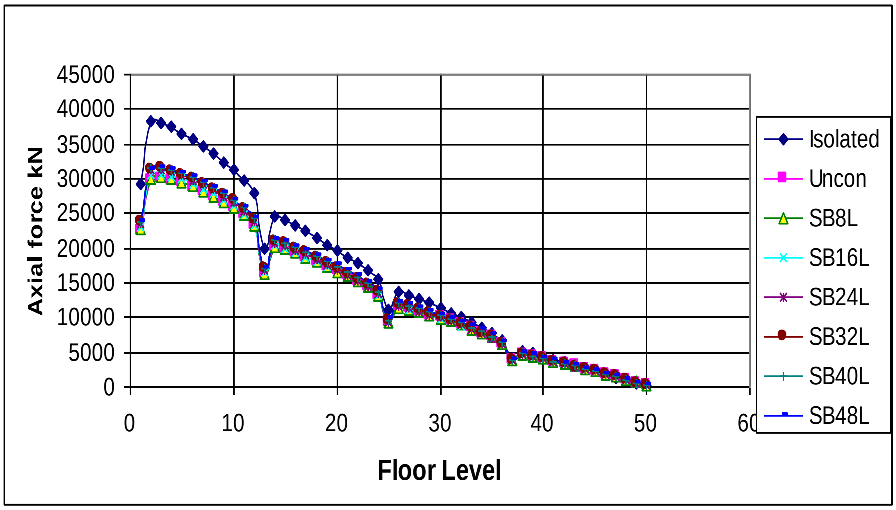

Fig. 11: Comparison of axial force in corner columns with floor levels at column 10101(at node 1 Building 1) for different cases at 90° wind incidence angle

V. CONCLUSIONS

The following conclusions are drawn from the present study.

a) There is no significant change in axial force in columns with change in wind incidence angle. However, as the angle increases the axial force in building 2 is marginally increased.
b) The connecting bridge does not have much effect on the axial force in columns.
c) Maximum axial force in columns is neither at 0° nor at 90° wind incidence angles. This holds good for isolated as well as two building case.
d) In building 1 of two building case (unconnected and connected at 90° wind incidence the axial force differs significantly from the axial force at other angles
e) In general the behaviour of diagonally opposite columns with regard to maximum/minimum axial force in columns is opposite in nature, i.e. if there is maximum axial force in a column at some angle then on diagonally opposite column there is minimum axial force at that particular angle.

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BIOGRAPHY

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