POSTER

Tower Block of Civic Center, Shah Alam Core Project, Malaysia

Tour du Centre civique, Shah Alam Core Project, Malaysie

Turmaufbau beim Civic Center, Shah Alam Core Project, Malaysia

C.R. ALIMCHANDANI
Chairman & Managing Dir.
Consult. Ltd.
Bombay, India

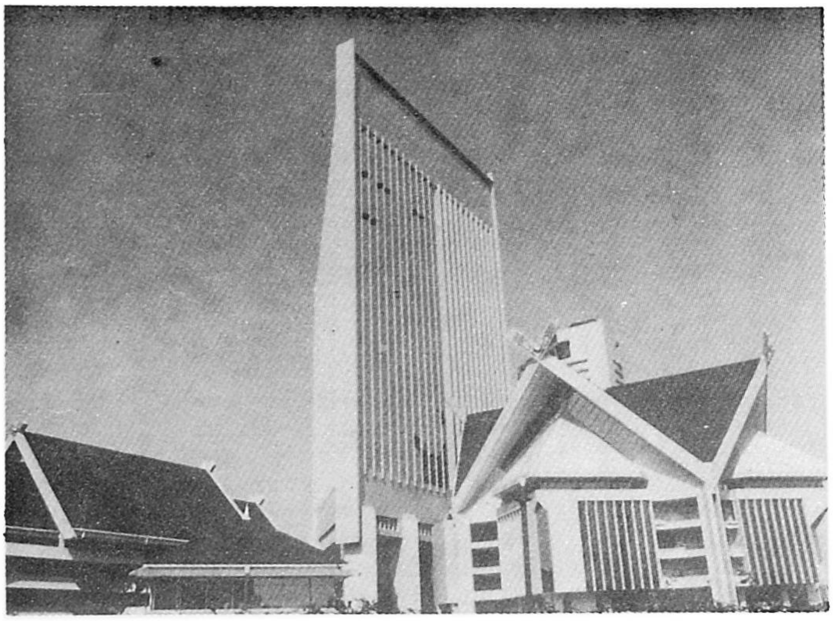
Harry Tan Kian HUAT
Kumarasivam Tan & ArrifinSTUP
Kuala Lumpur, Malaysia

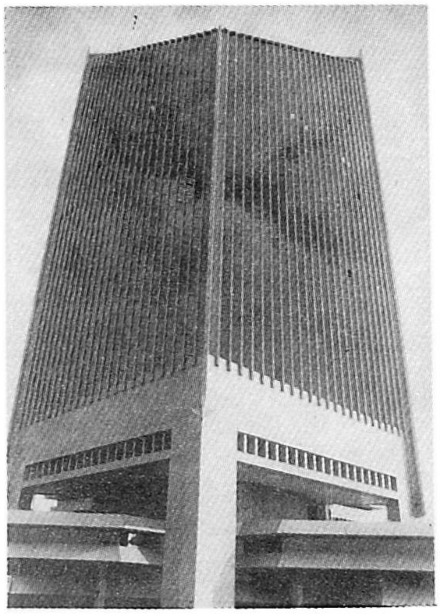
The civic centre at Selangor has three major buildings of striking architecture. The main civic office is housed in one of them - a building triangular in plan with two sides of 50 m at right angles and a 72 m hypotenuse.

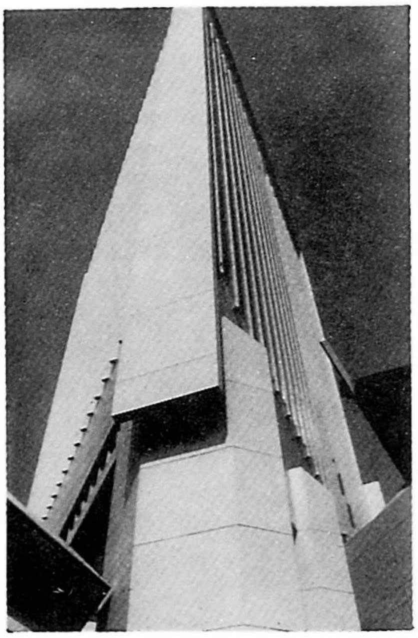
At the base is a concete podium of 4 m height above ground with a basement for car parking below. Above the podium, monumental columns at the three apices with two more intermediate columns along the longer side rise 20 metres to the soffit of 12 m (4 stories) deep transfer girders. In the centre of the building there is only a triangular shaft enclosing the lifts and services. The rest of the space is clear for a 20 m height giving a majestic appearance to the building.

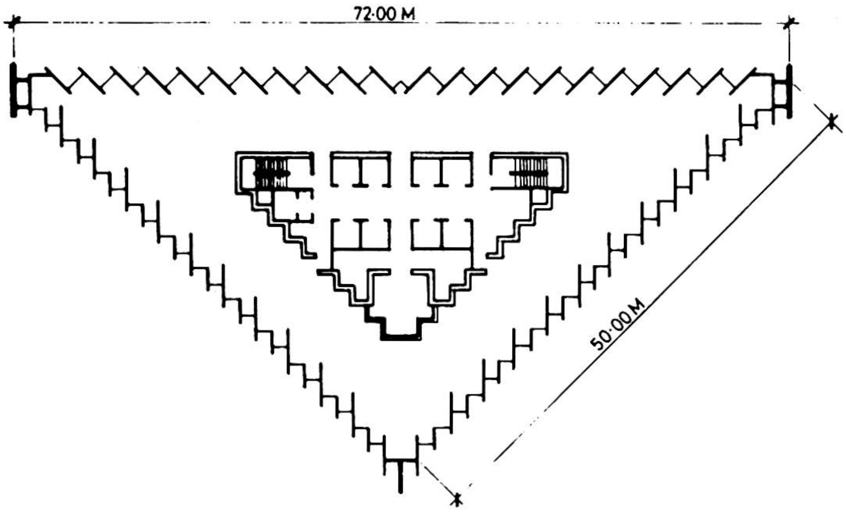
The tower rises 30 stories above the soffit level. The external triangular tower functions as a structural tube above the transfer girders. Each face is composed of a frame formed by RCC fins and transverse beams connecting the fins at every floor level. The inner trinagular tube carring the lift shafts and the services is of monolithic reinforced concrete. The outer and inner tubes are connected by floors. This permits the outer and inner tubes to carry vertical loads from the floors as well as to resist in tandem the wind loads. The floors provide lateral support to the external tube which has low lateral strength but good strength along the faces of the tube. The large transfer girders give rise to major variable deformations during construction and long term deformations in service that are as high as 15 cm. The differential temperature effects between the outer tube and the inner tube (the latter is an aiconditioned environment) adds differential vertical movement of the order of 15 mm. The floors have therefore to be articulated at supports on the inner and outer trinagular tubes.

The structure required very detailed analyses covering the structural behaviour and defomrations and appropriate and meticulous detailing. The prestressed concrete transfer girders which are monolithic with the columns act together as a space frame. Their analysis and detailing required special attention. Similarly the construction procedure for the 12 m deep and 4 m wide box transfer girders, constructed on staging 20 m to 32 m high, required very careful detailing.









TYPICAL FLOOR PLAN OF TOWER BLOCK

Tower Block of Civic Center, Shah Alam Core Project, Malaysia

Investigation of Frame with Semi-Rigid Joint

Essais de cadres à joints semi-rigides

Untersuchung von Rahmen mit halbsteifen Knoten

Siamak PARSANEJAD
Senior Lecturer
Univ. of Technology
Broadway, NSW, Australia

Ali SALEH
Lecturer
Univ. of Technology
Broadway, NSW, Australia

Bijan SAMALI
Senior Lecturer
Univ. of Technology
Broadway, NSW, Australia

SUMMARY

The effect of joint flexibility on the static and dynamic behaviour of moment resisting frames is being studied analytically and experimentally. A thirty three storey steel frame is analysed to demonstrate the effect of the joint flexibility on the horizontal deflections and the natural frequencies of vibration of the frame. Two near full scale frames are being tested. The behaviour of the joints and the frame are monitored concurrently. The analytical results and the testing program are briefly explained here and together with the experimental results are being illustrated on the poster in more detail.

DESCRIPTION OF WORK

Flexibility of joints has a significant effect on the behaviour of structural frameworks especially in high rise construction. It magnifies the lateral deflections which directly affect the serviceability of buildings and influence the stability of structures through the second order effects. Flexibility of joints also alters the dynamic characteristics of structures in terms of their natural frequencies, mode shapes and damping characteristics.

The results of a comparison made on a thirty three storey moment resisting frame made of steel is given in Table 1 and Figure 1. The frame consists of typical 3 x 8 m span x 3.6 m high storeys and has a contributary breath of 5 m perpendicular to the wind direction. The beams and columns are selected from rolled Universal Beams and Universal Columns respectively. The standard end plated connection with eight high strength bolts is used typically [1]. The frame was designed for a sway limit of 0.002 of the height when full rigidity was assumed for all connections.

The wind loading is determined based on the gust factor method of the Australian loading code [2] for a wind velocity of 41 m/s in a suburban terrain. The frame is loaded and analysed for three different conditions:

1. All joints are fully rigid.
2. All internal joints are rigid and all external joints are semi-rigid.
3. All joints are semi-rigid.

A small deflection elastic analysis is used. The semi-rigid joints are modelled as linear torsional springs at the beam ends. The springs stiffnesses were calculated as the secant stiffnesses of the joints using Yee and Melchers analytical model [3].

	Condition 1	Condition 2	Condition 3
First Natural Frequency (Hz)	0.185	0.173	0.141
Second Natural Frequency (Hz)	0.511	0.472	0.379
Percent of Critical Damping	2	3.5	5
Gust Factor, G	2.61	2.55	2.55
Wind Pressure at top of the Building (KPa)	1.44	1.40	1.40
Total Lateral Load (KN)	622	608	608
Top Floor Displacement (mm)	240	266	400

Table 1 Comparison of the analytical results

As shown in Table 1, the natural frequencies of the frame are marginally reduced by the flexibility of the exterior joints (less than 6% for Condition 2) The flexibility of the internal joints, however, has reduced the frequencies markedly (more than 18% for Condition 3). The effect of the joint flexibility on the gust factor, and consequently on the loading, is seen to be negligible. The horizontal displacements are affected in the same manner as the natural periods of vibration and is magnified by 67% at the top floor when the flexibilities of all connections are considered. The deflected shapes for Condition 1 and Condition 3 are shown in Figure 1. The damping for frames with Conditions 1 and 3 is assumed respectively as 2% and 5% of the critical damping as normally used in literature. For Condition 2, an intermediate value of 3.5% is assumed.

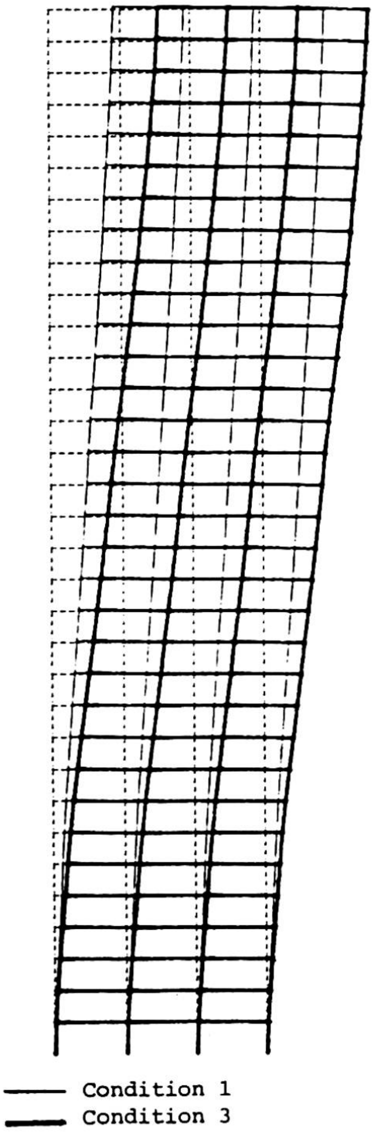


Fig. 1 Deflected Shape

To verify the above analytical procedures an experimental investigation of the frames containing semi-rigid joints is being conducted. Two near full scale single span pin based frames with standard end plated connections are tested. The geometric imperfections of the frames are fully surveyed. Non-destructive free vibration tests are performed for two different levels of amplitude and three different periods of vibration. The frames are then tested to failure statically. During these tests, the behaviour of the connections as well as the frames is monitored. The extent and spread of plastification is followed to near failure load during the static testing.

The frames are made of 150 UC 37.2 columns and 200 UB 25.4 beams. They are pin based frames with a span of 2.15 m and a height of 2.1 m approximately. The beams are fitted with 28 mm end plates, each being connected to the column with 8 M20 - 8.8 high strength bolts. Strain gauges are used to monitor the plastic zones. Four LVDT's (two on each side of the column) are employed to register the moment-rotation relationship of each joint. The joint rotation is defined as the change of the angle between the end plate of the beam and a horizontal line on the column at the level of the beam bottom flange. A LVDT and an accelerometer are used to register the horizontal response of the frame when subject to free vibration or to horizontal static leading. The experimental findings and their comparison with analytical results are illustrated on the poster.

REFERENCES

1. Aust. I.S.C., Standardised Structural Connections. 3rd Ed., 1985.

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3. YEE, Y.L. and MELCHERS, R.E., Moment-Rotation Curves for Bolted Connections, J. of Struct. Engr., ASCE, Vol. 112, No. 3, March 1986.

Structural Schemes for Lateral Load Resistance

Systèmes structuraux pour résister à des charges latéales

Tragsysteme für horizontale Einwirkungen

A.R. SANTHAKUMAR
Prof.
Anna University
Madras, India

Preamble

Majority of institutional buildings in India and New Zeland are moderately tall (6 to 10 stories). The resistance to lateral load in them are provided by rigid jointed frames, shear walls, prefabricated shear walls or frames infilled with bricks. This paper summarises the findings of experimental investigation of these systems subjected to lateral cyclic loads. The Systems considered are shown in Figure 1.

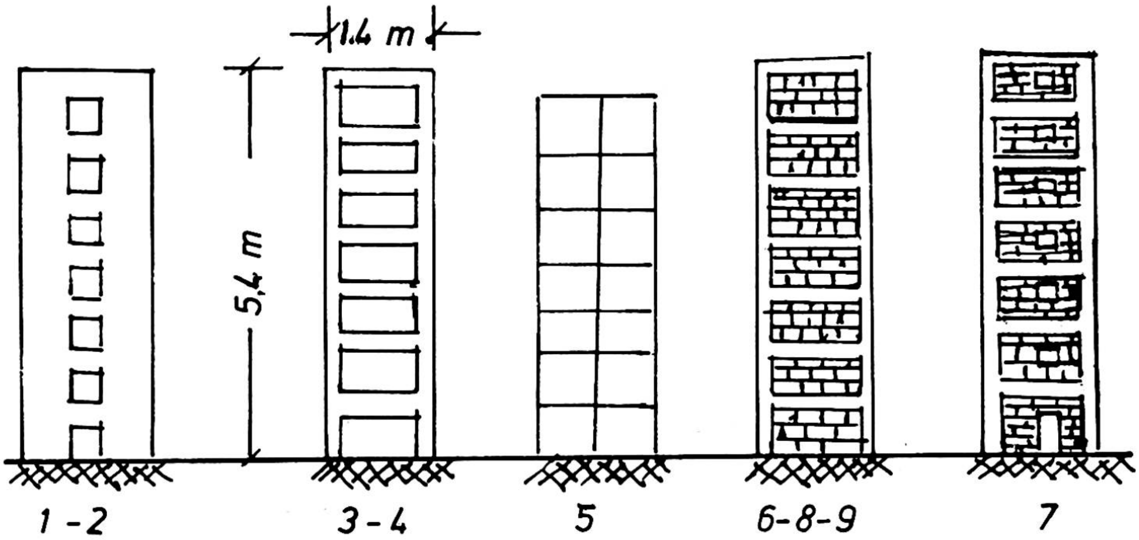

Fig.1 Systems Considered

Philosophy

The system efficiencies were studied with respect to

* Strength
* Stiffness
* Ductility
* Prefered sequence of failure and damage control.

Efficiency

The efficiency of the system is worked out using the equation

$$\eta = \frac{\mu P_u}{\mu_f \; P_{us}} \times 100$$

Where

η = Efficiency of the system
μ = Ductility of the system
P_u = Ultimate load of the system
u_f = Ductility of the rigid jointed frame
P_{us} = Ultimate load capacity of shear wall

Results

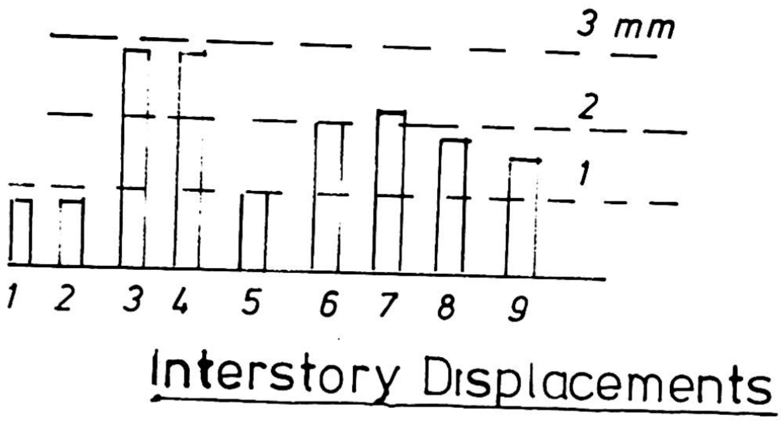

Fig.2 Results of tests on quarter full size seven storey models

Conclusion

The table summarises the relative efficiency of the systems.

System Number	Cumulative Ductility	Ultimate Load(Pu)kN	Efficiency %
1	50	237	29.6
2	85	300	63.7
3	90	72	16.2
4	100	70	17.5
5	80	312	62.4
6	12	147	4.4
7	18	131	5.9
8	20	97	4.8
9	16	161	6.4

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