State-of-the-art structural designs and axial shortening studies of super high columns in a tall building

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ABSTRACT: An under construction 28-storey reinforced concrete building was instrumented to observe its axial shortening behavior. A number of columns and core walls at 1st floor levels have been instrumented for axial shortening measurements. A brief outlines on the field experiment, the laboratory concrete testing program, and the method used to estimate long-term axial shortening is presented.

1 INTRODUCTION

In high-rise building, vertical concrete members i.e. columns and core walls undergo deformations due to creep, shrinkage and axial stress. The resulting deformation is known as axial shortening.

In particular buildings, core walls and columns are having different sizes, sometimes they are made from different grade of concrete and/or designed to take axial stresses of a much different level thus having differential in terms of axial shortening (differential shortening). Effects of excessive differential shortening between columns and core walls to the structure and service elements were reported.

It is essential that a reasonable structural evaluation is made and suitable correction measures are used to tackle the anticipated differential shortening in high-rise buildings.

2 EXPERIMENTAL DETAILS

2.1 Asia Centre – the newest financial centre on Sathorn road, Bangkok, Thailand

Asia Centre is a newly proposed 28 storey office tower, currently under construction and will be completed in the last quarter of 2008. The building comprises of a 28-storey office towers and an 8 storey parking (Fig. 1). Approximate rentable area is 40000 m². The structural designs and Post Tensioning System are supplied by PBL Group Limited.

2.2 Structural system and its implication on axial shortening

The structure of the main tower was designed as a reinforced concrete moment resisting frame which incorporates column bracing and long spans. The post-tensioned (PT) slabs (typical span 11 × 13 m, thickness 30 cm) is designed to act in resisting gravity loads Lateral and gravity load transferred to the perimeter concrete frame via a transfer system consisting of PT members.

The 1st level takes a span of 28 m which is support by PT slab and beam system. Note that transfer beam at 8th level (i.e. 1st office level) is designed as a part of a rigid PT frame. It is supported on two columns with a height of 20 m (Fig. 2; note the space between 1st to 8th levels).

Due to its structural complexity and the uniqueness of the floor height at 1st floor, a comprehensive study on differential shortening has been commenced at Asia Centre construction site. A Demountable Strain Gauge (DEMEX) is employed for on-site strain data
collection. In addition, concrete properties that closely related to axial shortening i.e. compressive strength, elastic modulus, shrinkage and creep are conducted simultaneously in the laboratory.

The tested properties of site concrete and actual axial stress according to as-built construction history will be employed in an axial shortening prediction process which Age Adjusted Effective Modulus method (AEMM) is adopted. Ultimately, comparison between predicted axial shortening and the data readings taken from the site will be made to verify the performance of the structure.

AEMM Method (Bazant, 1972) takes the following form:

$$\varepsilon^*(t,s) = \frac{\sigma_0}{E_c(s)} \left(1 + \frac{\Delta\sigma(t)}{E_c(s)} \right) \left(1 + \chi(t,s)\phi(t,s)\right)$$ (1)

where $\varepsilon^*(t,s)$ = total strain at time t of a reinforced concrete member loaded initially at time s; $\sigma_0$ = initial stress applied to a concrete specimen; $\Delta\sigma(t)$ = the change in concrete stress at time t due to concrete relaxation; $\chi(t,s)$ = the ageing coefficient; $\phi(t,s)$ = the creep coefficient.

2.3 A brief description of the experiments

Axial shortening data of the four main columns (C1/C1A), perimeter columns (C2/C3) and core wall at 1st floor level will be obtained at regular intervals during the construction (Fig. 3). These columns/walls are different in loading, size and shape and therefore are required to be monitored for their differential shortening (Table 1). Results from C1, C1A, C2, and C3 will be compared to those obtained from core walls to ensure that the actual differential shortening between columns and core walls that occurred on site is in the acceptable range.

### Table 1. Columns and core walls instrumented details.

<table>
<thead>
<tr>
<th>Column/wall ID</th>
<th>Sectional area (Sq.m)</th>
<th>Axial stress (MPa)</th>
<th>DEMEC points nos</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>4.76</td>
<td>9.80</td>
<td>2 side x 6 stations</td>
</tr>
<tr>
<td>C1A</td>
<td>4.03</td>
<td>11.1</td>
<td>2 side x 6 stations</td>
</tr>
<tr>
<td>C2</td>
<td>1.85</td>
<td>21.0</td>
<td>2 side x 6 stations</td>
</tr>
<tr>
<td>C3</td>
<td>0.86</td>
<td>13.3</td>
<td>2 side x 6 stations</td>
</tr>
<tr>
<td>W1</td>
<td>0.30</td>
<td>8.83</td>
<td>1 side x 6 stations</td>
</tr>
<tr>
<td>W2</td>
<td>0.30</td>
<td>8.83</td>
<td>1 side x 6 stations</td>
</tr>
</tbody>
</table>

Note: Concrete strength at 28 days = 40 MPa; * per 1 m.

In addition to the strain measurements, concrete samples have been collected and tested for the required time dependent mechanical properties including the compressive strength, elastic modulus, drying shrinkage and creep.

3 CONCLUSION

Axial shortening data of columns and core walls on Asia Centre has been collected. Details of the data collection on site, the laboratory testing and the analytical method adopted are briefly outlined. Work is underway in accessing the accuracy of the predicted axial shortening using AEMM method as compared to the field data.

REFERENCES
