COMPARATIVE STUDY OF WIND CODES TO BE USED FOR TALL BUILDINGS IN SRI LANKA

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INTRODUCTION

Iconic tall buildings are coming up in and around the city of Colombo undergoing rapid changes after a thirty year civil war showcasing the development process. This has forced structural design engineers to pay more attention regarding the effects of wind forces on tall buildings which received less attention earlier. As a result of the cyclone which severely affected eastern and north eastern coastal areas in 1978, Sri Lankan Government introduced "Design of Buildings for High Winds, Sri Lanka" (1980) to be followed when designing buildings for high winds. This was based on CP-3 Chapter-V, part-2:1972 and the document is more suitable to be applied for design of low rise buildings. However, following factors were not addressed by this document.

- Change of wind pressure with the altitude
- Deflection
- Human comfort
- Feasibility of environmental impact

Sri Lankan structural design engineers use various international wind codes when designing tall buildings to address the above issues. This study was carried out as a comparative study to identify the most appropriate wind design code to be used when designing tall buildings by Sri Lankan structural design engineers emphasizing the safety and comfort of the occupants.

METHODOLOGY

Wind Codes

In this study, four different wind codes, namely CP3 Chapter-V Part-2:1972, BS 6399.2:1997, AS/NZS 1170.2:2011 and BS EN 1991-1-4:2005 are compared with respect to CP3 Chapter-V Part-2:1972. Two different configurations of buildings; 30m x 40m x 54m high located in wind zone 3 and 40m x 60m x 180m high located in wind zone 1 were analyzed applying the wind loads recommended in the four different design codes using a structural design software.

Basic Wind Speeds

Selected wind codes use different average times to calculate wind loads. CP3 Chapter-V Part-2:1972 has sub divided Sri Lanka into three different zones as shown in Figure 1 and three second wind gust speeds are available for these zones. Wind speeds used for the three zones to determine the wind loads based on different average times recommended in each wind code are tabulated in Table 1.

Structural Analysis of Selected Buildings

The buildings were designed as typical column - beam frame structures of reinforced concrete. Structural analysis was done using a structural design software assuming typical details for structural element sizes and shear cores. The structures were analyzed for each wind code mentioned above, with the completed data of the wind load calculations and structures were modeled for each wind code. The models were analyzed for the ultimate limit state load combinations. Wind drift caused by the wind loads recommended by each wind

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code was also determined.

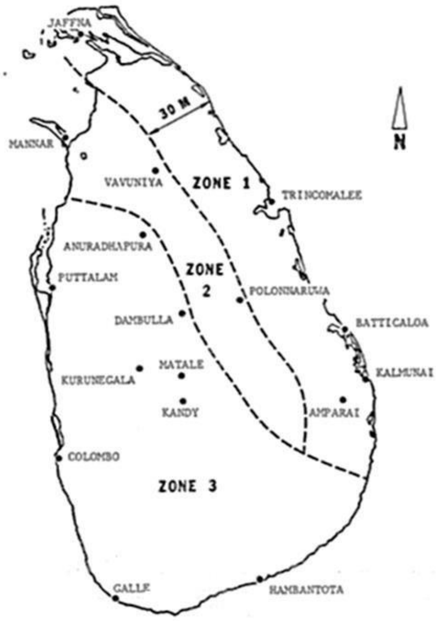

Figure 1. Wind loading zones in Sri Lanka

A methodology to carry out wind induced accelerations is provided only by the wind codes AS/NZS 1170.2:2011 and BS EN 1991-1-4:2005. Out of these two codes, AS/NZS 1170.2:2011 facilitates calculation of acceleration on cross wind direction in addition to the along wind direction. Wind induced accelerations for both building models were carried out according to the guidelines given in these two wind codes.

Table 1. Basic wind speeds with different average times used with different wind codes

	Zone 1		Zone 2		Zone 3	
	Normal Structure	Post Disaster Structure	Normal Structure	Post Disaster Structure	Normal Structure	Post Disaster Structure
3 second gust wind speeds for CP3: Ch.V Part-2:1972	49	54	43	47	33	38
Mean hourly wind speeds for BS 6399.2:1997	27	30	24	26	18	21
3 second gust wind speeds for AS/NZS 1170.2:2011	49	54	43	47	33	38
Ten minute mean wind speeds for BS EN 1991-1-4:2005	28	32	25	28	19	22

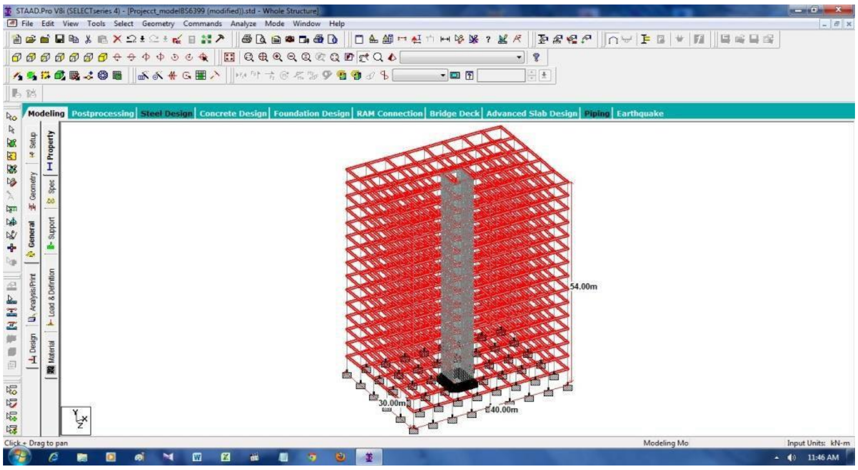

Figure 2. Model prepared using the structural design software for 30m x 40m x 54m Building

RESULTS AND DISCUSSION

Drift Index

Wind drift of the buildings need to be maintained at lower values: to prevent damages to cladding, partitions and interior finishes; to reduce the effect of motion of perceptibility etc. BS8110: Part 2, 1985 recommends a maximum allowable deflection of (l/500). The calculated values for the two cases are summarized in Table 2. BS EN 1991-1-4:2005 produced the highest wind induced drift according to the result.

Table 2. Drift index for different wind codes

Wind code	30m x 40m x 54m Building in Zone 3	40m x 60m x 180m Building in Zone 1
CP3: Ch.V Part-2:1972	l/2235	l/1050
BS 6399.2:1997	l/2162	l/1072
AS/NZS 1170.2:2011	l/1906	l/876
BS EN 1991-1-4:2005	l/1847	l/718

Column Loads

BS EN 1991-1-4:2005 produced the highest axial forces, shear forces and bending moments in ground floor columns.

Bending Moments

BS EN 1991-1-4:2005 produced the highest bending moments in first floor beams.

Shear Forces

BS EN 1991-1-4:2005 produced the highest shear forces in first floor beams.

Wind Induced Acceleration

AS/NZS 1170.2:2011 wind code produced the higher values for wind induced acceleration than BS EN 1991-1-4:2005 code. However, all the values are lower than the recommended peak acceleration, 0.200 ms-2, at the design wind speeds.

Table 3. Wind induced accelerations

Wind code	Accelerations (ms^{-2})							
	30m x 40m x 54m Building				40m x 60m x 180m Building			
	Wind normal to 40m side		Wind normal to 30m side		Wind normal to 60m side		Wind normal to 40m side	
	Along wind	Cross wind	Along wind	Cross wind	Along wind	Cross wind	Along wind	Cross wind
BS EN 1991-1-4:2005	.012	-	.008	-	.030	-	.018	-
AS/NZS 1170.2:2011	.019	.065	.016	.049	.057	.127	.042	.119

CONCLUSIONS/RECOMMENDATIONS

Based on the outcomes of this comparative study it can be concluded that Euro code BS EN 1991-1-4:2005 produces the highest levels of stresses and deflections in both building models used for the analysis. Considering the huge investment one has to make to construct a tall building it can be concluded that the Euro Code BS EN 1991-1-4:2005 would ensure the safety and comfort of the occupants of tall buildings when used to model the wind effects on the building.

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