Dynamic Response of Reinforced Concrete Buildings with Coupled Beams

R. Harsha Vardhan Reddy, S. Elavenil

Abstract: ***Resistance of a building against seismic forces is one of the practical design parameters that considered while designing as well as during construction. In addition to the parameters, structural ponding is also a problem that occurs when the buildings are spaced closely during the earthquake. However, the functionality and objective of these buildings are different, which translates into different dynamic systems. Many techniques have been introducing and developing to design the structures safe. Coupling and bracing are some of the methods which hold the building together and act as a single inverted pendulum during the earthquake. In the present study, a horizontally coupled building system of 20 storey's is developed separately with coupled beams and bracing systems. It is assumed that the two adjacent buildings were similar in this coupled building system, so the two adjacent stories could be coupled at the same height by an inter-building. And coupling with beams is introduced at different storey's in the building, and results reveal that the building coupled beam at all storey showed the performance of the building in terms of displacement, storey drift, and storey shear.***

Keywords: Coupled buildings, Twin buildings, Bracing system, Seismic performance

I. INTRODUCTION

The architectural design of high-rise buildings in recent decades has become ever more new and spectacular and led to a range of external and seismic behaviors [1]. More and more high-rise buildings are being built in the city because of inadequate land availability in populated areas, particularly in major cities [2]. As a consequence, in the comparatively adjacent building environment, there is a growing trend to build high-rise towers. There are different types of ties, such as fixed, semi-set, and hinged [3]. This medium is a network composed of a variety of constructs combined with external relations such as sky-gardens and sky-bridges [4]. The Petronas Twin Towers in Malaysia and the Marina Bay Sands Hotel in Singapore are two fantastic examples of this phenomenon. Intrinsically, in the field of structural design, the seismic response is the primary concern, since the structural reaction relies fundamentally on many factors, such as earthquake conditions, soil type and structural materials [5]. That could be used in static, fluid, linear, or non-linear environments to evaluate different kinds of engineering problems [6]. In the finite-element system methods used in industrial and university work, ETABS is considered the most flexible and feasible process [7]. This medium provides active research for phenomena such as seawater and longitudinal earthquake loads. Various researchers reported extensive research on seismic reactions for each high-rise structure [8]. Besides, several studies focused on wind-induced responses of connected building systems connected via structural links have been published [9]. Such activities have shown an excellent understanding of the complicated reaction of these buildings. Many important issues have been identified with the construction of these windproof frameworks [10]. Nevertheless, in the open literature, only some seismic reactions to the coupled building systems could be found, given the considerable complexity of this issue [11]. In effect, there are analogous twin structural systems, which were connected by non-structural members, in addition to the abovementioned connected building systems where neighboring buildings were connected via structural links [12]. This thesis studied the association of twin towers with a structural relationship and examined the impact on the seismic reaction of the related property, including the position and distance.

A. Background

The idea is to allow two systems that are functionally different from each other to exercise control forces to reduce the overall device responses. In the United States, Klein et al. (1972) and subsequently, Kunieda (1976) introduced partnered construction regulation 30 years ago.

II. ANALYTICAL INVESTIGATION

The building to be analyzed is a G+20 RC building with different locations of coupled beams and with the braced coupled building. It has been modeled in ETABS software and analyzed for the response spectrum, and results show the performance of the building. The following load combination is being considered in the design.1.2 (Dead Load + Live Load + Floor Finish + Earthquake Load).

A. Basic Plan

The building is modeled as a bare framed structure. For the Analysis, a typical frame plan dimensions of 56 × 56 m and height 60 m are taken into account. The dimension is taken on the X-direction, and Y-direction and Z-direction are taken in the vertical direction. Along the longer dimension in the plan, eight bays are through-about, having a span of 6 m. Along the shorter direction, five bays are thought-about, having a span of 6 m. The storey height is taken as 3m.

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B. Building Specifications

The primary data regarding the geometry of the frame considered in this paper is given in Table 1.

Table- I: Specifications of the Building

Seismic zone	1V
Soil type	Medium stiff soil
Floor height	3m
Width along X-direction	51 (8 bays)
Width along Y-direction	54 (9bays)
Columns - RCC	750 × 230 mm
Beams	230 × 500 mm
Depth of slab	150
Clear cover of beam	25 mm
Clear cover of column	40 mm
Importance factor	1.5
Flange thickness	9.7mm
Materials	M25 Grade concrete &Fe 500 Reinforcement
Zone factor	0.16
Unit weight of concrete	25 kN/m^3

C. 3D Modeling of the Building

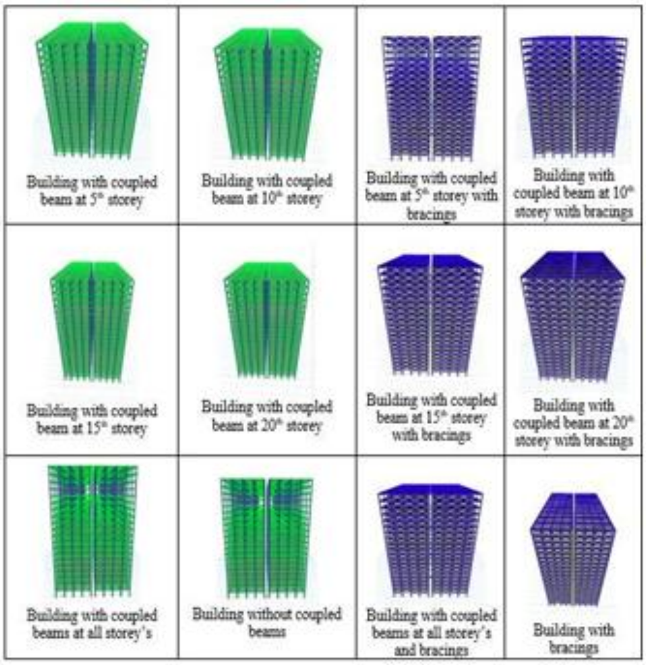

Fig. 1. 3D Modeling of buildings with coupled beams and bracings at different storey's

III. ANALYSIS OF RESULTS

From the response spectrum analysis, the following results are obtained. Figure 2 represents the displacement of the building with and without a coupled beam at different storey's. Initially, without a coupled beam, the maximum displacement obtained at 15th storey, i.e., 17.28 mm. after introducing the coupled beam at 5th, 10th, 15th,20th, and all storey the displacement is 16.9,16.75,16.70,16.85 and 15.37 mm. So the displacement is reduced to 15.37 mm.

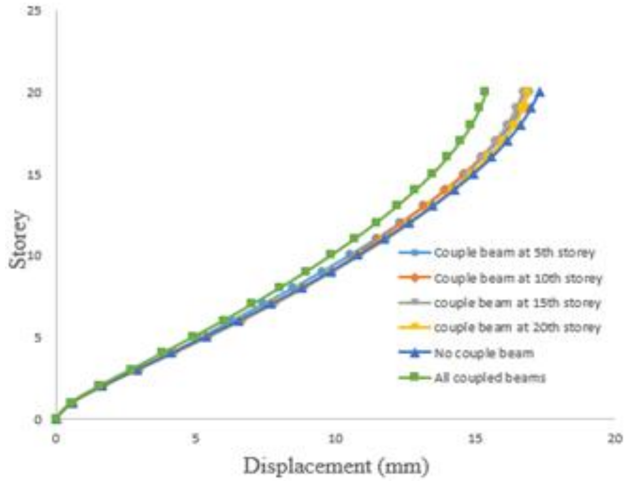

Fig. 2. Displacement of buildings with and without coupled beams at different storey's

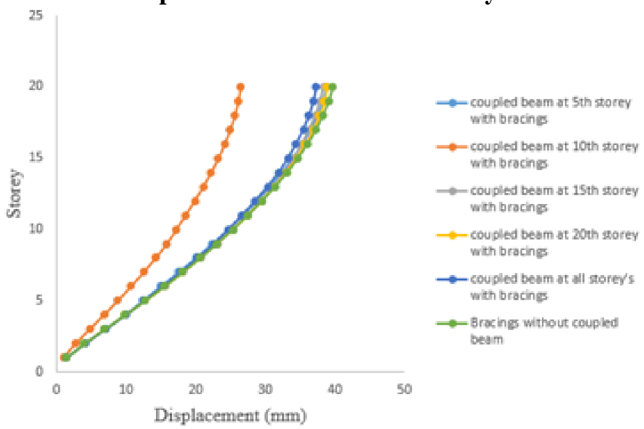

Fig. 3. Displacement of buildings with bracings and coupled beams at different storey's

Figure 3 represents the displacement of the building with bracings and coupled beams at different storey's. The maximum displacement of all the buildings is almost the same, i.e., nearly 40 mm except the building with bracings and coupled beam at 10th storey. The obtained maximum displacement is nearly 25 mm.

Figure 4 and 5 represents the storey drift of the buildings with coupled beams at different storey's and coupled beams at different storey's with bracings. From Figure 4, the storey of all the buildings is almost the same, and coupled beams at all storey's are less compared with other buildings. From figure 5 coupled beam at 10th storey with bracings having less storey drift. It is also observed that coupled beam at 5th storey and all storey's with bracings having same storey drift. And both coupled beam 20th storey and building with only bracings are having the same storey drift.

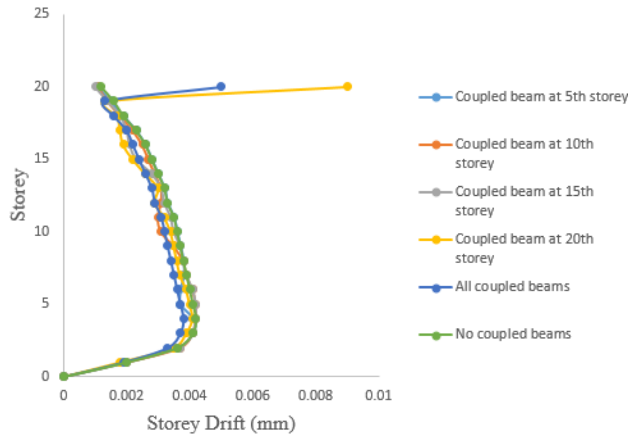

Fig. 4. Storey drift of the buildings with and without coupled beams at different storey's

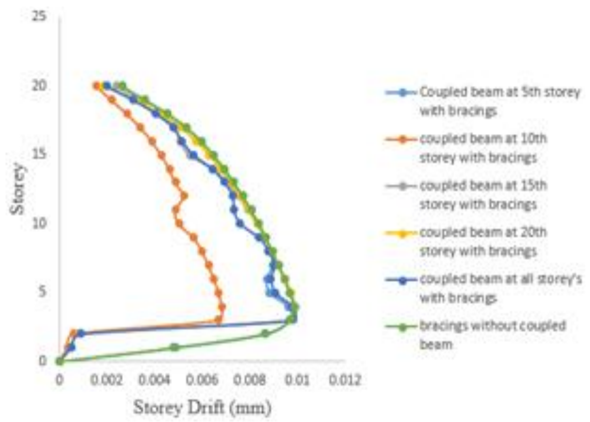

Fig. 5. Storey drift of the buildings with bracings and coupled beams at different storey's

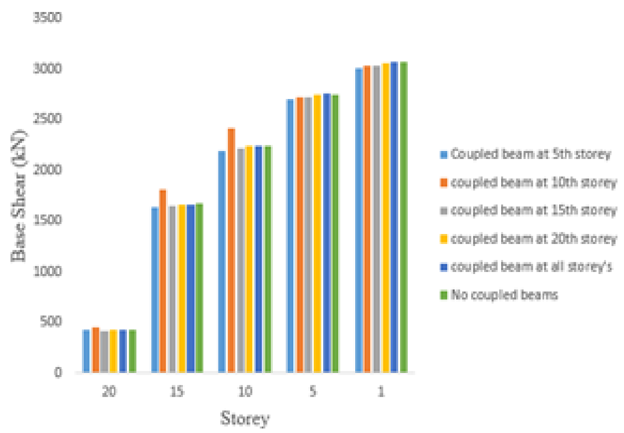

Fig. 6. Base shear of buildings with and without coupled beams at different storey's

Figure 6 and 7 represents the base shear of the buildings with coupled beams at different storey's and coupled beams at different storey's with bracings. From Figure 6, the base shear of the building of all the buildings with and without coupled beams are the same. So even if we introduced the coupled system the storey shear is almost the same in the bottom storey. But at 10th storey and 15th storey, the base shear is more than a coupled beam at other storey's.

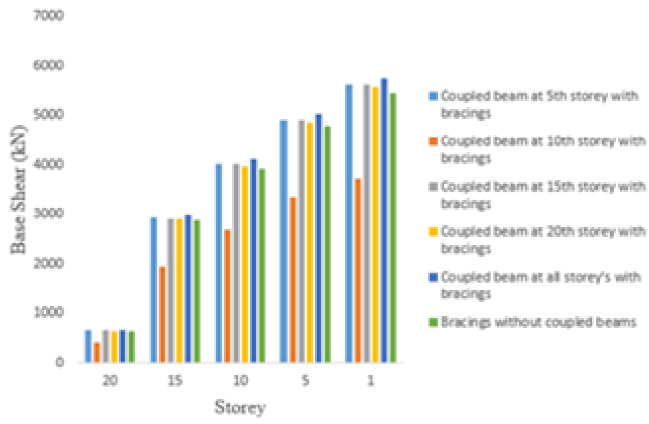

Fig. 7. Base shear of buildings with bracings and coupled beams at different storey's

From Figure 7, the base shear of the buildings coupled at all storey having more base shear followed by coupled beams at 5th storey, 15th,20th storey at the base. At all the other storey also coupled beam with bracings is more at all storey's

IV. CONCLUSIONS

The dynamic performance of the building with the application of coupled and bracing system has been evaluated in this study, and the following results have been drawn.

i. The building with the coupled beam at all storey's showed the best performance. i.e., 23% less displacement compares with the coupled building at all other storey's.

ii. Buildings with both bracings and coupled beams at 10th storey showed the best performance, i.e., 40% less displacement compare with coupled beams at 5th and 15th storey

iii. The storey shear has more for the buildings with coupled beams at 5th,10th,15th,20th storey with bracings, i.e., nearly 27% is more than the building with all coupled beams

iv. The storey Drift is nearly 20% is more for buildings with bracings than buildings without bracings, and coupled buildings and the storey drift of coupled building different storey's showed almost same storey drift

v. Base shear of building with the coupled beam at 10th storey is less than **all other buildings and coupled beam with bracings have more base shear than the other buildings with bracings and coupled beams**

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