OPTIMUM MOMENT DISTRIBUTION BETWEEN SHEAR WALLS AND
BOUNDARY BEAMS OF COUPLED SHEAR WALL WITH FLANGE WALLS

MAKOTO KATO and KEN-ICHI SUGAYA and NORIKAZU NAGATSUKA

Structural Engineering Department, Building Research Institute, Ministry of Construction,
1 Tatehara, Tsukuba City, Ibaraki, 305 Japan

ABSTRACT

The center-core type coupled shear walls that have flange walls, and are connected by coupling beams, have a merit in planning to take a wide space around them. As the main seismic structural members of the building are the coupled shear walls, the performance of this shear walls dominate the seismic capacity of the building. And it is necessary to establish the design methodology of this shear walls. This paper introduces the analytical and experimental research on the optimum moment distribution between the shear walls and coupling beams. The results show the optimum moment carrying ratio and the required base shear coefficient so as to satisfy the preliminary seismic design criteria.

KEYWORDS

Base shear coefficient ; center-core ; coupled shear walls ; coupling beam ; optimum moment distribution.

INTRODUCTION

In the US-Japan Cooperative Structural Research Project on Composite and Hybrid Structure, a building with center-core type shear walls and exterior steel frame is selected as a prototype building for research. Figure 1 shows a plan of prototype building. The center-core type shear walls have flange walls, and are connected by coupling beams together. That is so-called a coupled shear walls. This type of building has a merit in planning to take a wide space around them. As the center-core shear walls and the exterior steel frame are not connected rigidly, the main seismic structural members of the prototype building are the coupled shear walls. Therefore the performance of this coupled shear walls dominate the seismic capacity of the building, and it is necessary to establish the design methodology of these shear walls.

This paper is the analytical research on the optimum moment distribution between the shear walls and coupling beams. The optimum moment carrying ratio and the required base shear coefficient are discussed in order to satisfy the preliminary seismic design criteria that are the drift limit of coupling beams of 2%, and no allowance of flexural yield of coupled shear walls. The result of this analytical research is reflected in design methodology of the test specimen. The experiment will be conducted in February 1996. The experiment will show the results that shear force distribution among walls in the tension and in the compression sides respectively, and the restoring force characteristics of shear walls.
TARGET BUILDING

The twelve stories building is selected among several prototype buildings. Coupled shear walls in the twelve stories building is under severe design condition for the shear force and for the drift control comparing with the lower or the higher building. The lower building could be designed by the strength resisting concept. And the higher building is necessary to provide some seismic elements, that is hat truss or belt truss which reduces the drift and the over-turning moment of walls. Figure 2 shows the conceptual drawing of these structural system.
Fig. 3 The plan and elevation of the test specimen modeled to T-shape walls

**ANALYSIS**

**Analytical Model**

The target building is modeled into a simple frame as shown in Fig. 4. Column represents the all shear walls, and coupling beams also do all coupling beams existing in the prototype building. The lateral shear carried by steel frame against the total shear is small enough to neglect the effect of steel frame. Lateral load capacity of this prototype building is about 0.39 in terms of base shear coefficient.

Restoring force characteristics of wall used in this analysis is illustrated in Fig. 5. Origin oriented model up to yield point, and after that degrading trilinear model are applied to. Yield point is determined by the pre-analysis of section under uniform moment distribution condition along the member axis. Degrading trilinear model is applied to the restoring force characteristics model for coupling beam. Yield point and other parameters for model are determined based on the test result of coupling beam. The seismic test of coupling beam were conducted to know the typical seismic behavior of its. Damping coefficient to a tangent stiffness is assumed to be 3%.
Fig. 4  Analytical model of the prototype building modeled into a simple frame

Fig. 5  Restoring force characteristics of wall

Variables

Variables are the over-turning moment carrying ratio of coupling beams to the total over-turning moment; those are 4 cases from 20% to 80%. Cases of analysis conducted in this paper are listed in Table 1. Lateral load capacity of analytical model is about 0.39 in terms of base shear coefficient.

Table 1  Cases of analysis

<table>
<thead>
<tr>
<th>Cases of analysis</th>
<th>The over-turning moment carrying ratio of coupling beams and coupled shear walls to the total over-turning moment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coupling beams</td>
<td>Coupled shear walls</td>
</tr>
<tr>
<td>B20:W80</td>
<td>20%</td>
</tr>
<tr>
<td>B40:W60</td>
<td>40%</td>
</tr>
<tr>
<td>B60:W40</td>
<td>60%</td>
</tr>
<tr>
<td>B80:W20</td>
<td>80%</td>
</tr>
</tbody>
</table>
Static Analysis

Static load incremental non-linear analysis are conducted against analytical model. Lateral load distribution along the height is specified by Japanese Building Code as shown in Fig. 6. Figure 7 shows the shear of the 1st. story and the displacement of the top floor relationship. In case that over-turning moment carrying ratio of beam is smaller, beams yield prior to wall; cases of B20:W80, B40:W60, and B60:W40. And flexural yielding of beams and wall is almost same in case that over-turning moment carrying ratio of beam is greater; case of B80:W20.

![Analytical model](image)

Fig. 6 Lateral load distribution along the height

![Shear and displacement](image)

Fig. 7 The shear of the 1st. story and the displacement of the top floor relationship

Dynamic Analysis

Input ground motion used in the dynamic analysis is an artificial earthquake wave whose response spectrum covers several type of typical recorded earthquake responses, and its intensity is the largest expected at a construction site. In dynamic analysis, intensity of this earthquake is changed from 100 to 500 gal by every 100 gal. Figure 8 shows response spectrum of its.
RESULTS

The Story Drift and the Deformation of Coupling Beam

Figure 9 shows maximum responses on the deformation of the upper story. The story drift and the deformation of coupling beam of the upper story become larger in proportion that the moment carrying ratio of coupling beams is smaller. And when intensity of input ground motion is larger, response of those become larger.

On the other hand, when the moment carrying ratio of coupling beams becomes larger, or intensity of ground motion is larger, the foot of shear wall becomes easily to yield in flexure, then the story drift of the 1st. becomes larger. Maximum responses on the deformation of the lower story is shown in Fig.10.
The Bending Moment and the Shear Force

Figure 11 shows the bending moment and the shear force of the 1st. story. The bending moment at the foot of coupled shear walls decreases in inverse proportion to the moment carrying ratio of coupling beams. However, the shear force of the 1st. story of the coupled shear walls increases in proportion to that.

CONCLUSION

The moment carrying ratio of coupling beams to the total moment has influence on flexural yielding at the foot of coupled shear walls and the required ductility of coupling beam. In order to satisfy the preliminary seismic design criteria that are the drift limit of coupling beams of 2%, and no allowance of flexural yield of coupled shear walls, the optimum moment carrying ratio of coupling beams is 40% to 60%. In this connection, the moment carrying ratio of coupling beams of test specimen is 40%, lateral load capacity of its aims at 0.35 in terms of base shear coefficient.
ACKNOWLEDGEMENTS

This work has been financially supported by the US-Japan Cooperative Structural Research Project on Composite and Hybrid Structure. The authors would like to acknowledge Prof. H. Aoyama, chairman of Technical Coordinating Committee, Prof. A. Wada, chairman of Hybrid Wall System Technical Sub-Committee, Dr. M. Teshigawara, Building Research Institute, Ministry of Construction, and all members of the Project for their useful advises and suggestions.

REFERENCES


