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[Research Topics]

Deformation Capacity Improvement of The Steel Frame with Total Collapse Mechanism using Ultra-High Strength Steel

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1. Introduction

In recent years, attention to pulse type earthquakes that cause large displacement responses are concentrated. Some of them are predicted much higher than the level used in the current design, so it is promoted to set new seismic waves for design and to study about new design methods[1)]. To reduce damage of buildings against large earthquake, it has been considered to increase the elastic limit deformation using high strength steels in columns and girders[2),3)]. In this study, on the contrary, we propose the frames using hybrid H-section columns consist of flange with ultra-high strength steels and web with conventional strength steels, and conventional girders. In the case of using the high strength steel in columns, it is difficult to avoid the column bases of the first story being plasticized in the ultimate state. So, we consider the column base models showing stable behaviors against excessive earthquake ground motion[4)].

2. Frame using hybrid H-section columns

We show the damage reduction effect of the frames using hybrid columns and conventional girders(Fig.1) by using fish bone shaped models that are taken out of single-spans from multi-layer multi-span flat frames have uniform members(Fig.2). In addition, it was also evaluated from the cost effectiveness.
We obtained the following results.
(1) The frames using hybrid columns and conventional girders, compared to the frames using conventional columns and girders composed of thickened plate, have same degree of the proof stress and the cost, and also reduced more damage.
(2) By using the frame using hybrid columns and conventional girders, we can design a high earthquake resistance building without an increase in significant cost compared to a building designed with existing standards.(Fig.3)

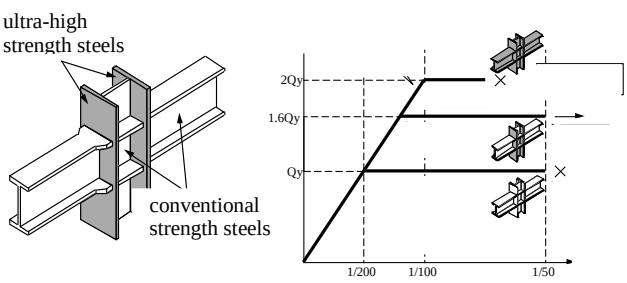


Fig.1 Concept of proposed structural system

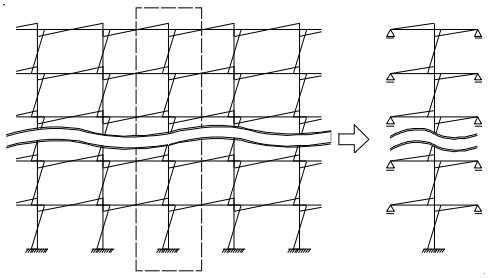
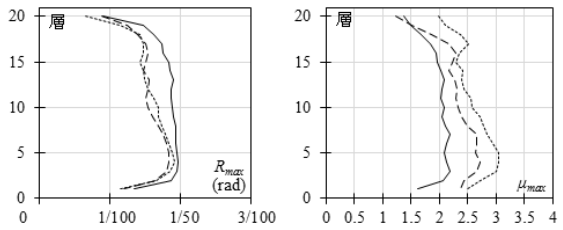
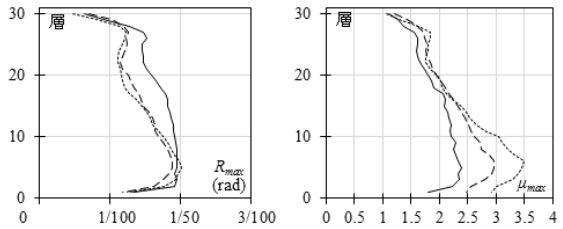


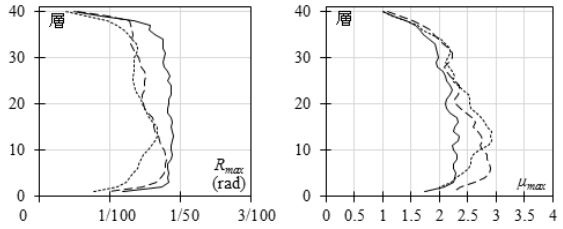
Fig.2 Fish bone shaped models that are taken out of single-spans from multi-layer multi-span flat frames



(a) story drift angle（20stories） (b) ductility factor（20stories）



(c) story drift angle（30stories） (d) ductility factor（30stories）



(e) story drift angle（40stories） (f) ductility factor（30stories）

Conventional structural system
proposed structural system

Fig.3 Response against pulse wave

3. The column base models against excessive earthquake ground motion.

We propose the column base models which show stable behaviors against excessive earthquake ground motion (Fig.4,5). After understanding the static behavior by finite element models and multi-spring models, we evaluated the performance during earthquake by defining the index called the limit magnification. With H-SA700 as a ultra-high strength steel and SN490 as a conventional strength steel, assuming inner columns of high-rise buildings, using column base sections of small width-thickness ratio, we obtained the following results.

(1) To increase the limit magnification in the column bases of the first story against excessive input, it is effective to have a deformation capacity without plasticizing of high strength steels of hybrid columns (Fig.6).

(2) The model obtained by adding a ultra-high strength steel in the center of the H-section composed of conventional steel can show stable behavior against about 2 times the level which is the largest Uemachi fault zone seismic. In addition, the superstructure reaches the deformation limit before the column base reaches the limit state. As a result, the performance of the building as the total collapse mechanism can be sufficiently exhibited (Fig.7).

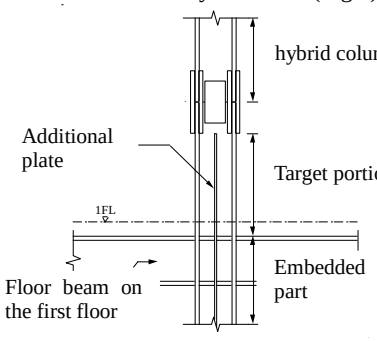


Fig.4 Assumed column type

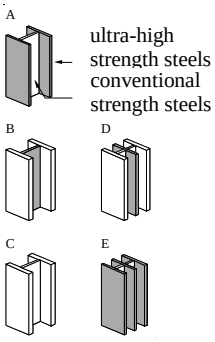


Fig.5 Models to consider

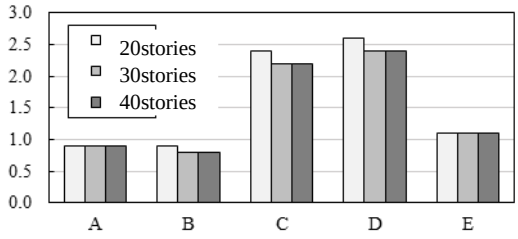


Fig.6 Magnification to reach the limit state

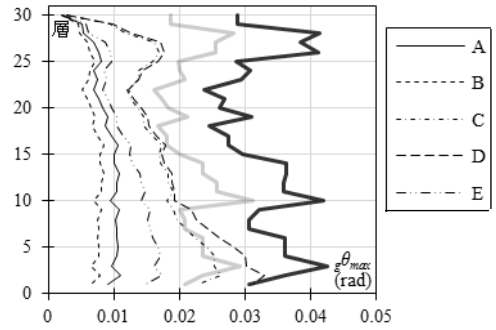


Fig.7 The superstructure reaches the deformation limit before the column base reaches the limit state

4. Conclusions

We proposed the frames using hybrid H-section columns consist of flange with ultra-high strength steels and web with conventional strength steels, and conventional girders. Moreover, we proposed the column base models showing stable behaviors against excessive earthquake ground motion. In the future, we are going to research the combination of steel species, effects of varying axial force, the case of using column base sections of large width-thickness ratio. On the other hand, Research on the application of the frames using hybrid columns and conventional girders is under way by experiments using the test piece of the column members and the cross structures. In addition, we are going to research the behavior of the column bases by experiments.

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