

THE RESEARCH ON SEISMIC EVALUATION AND RETROFIT OF CONDOMINIUM IN JAPAN

NAKANO TOKIE, Dr. Eng. ,NTT Facilities Research Institute

ABE SHIGETAKA, NPO Corp. PASTS

2018 November 13th Queens Town in New Zealand

1. Introduction

- Earthquakes like local earthquakes just under the city and ocean-trench earthquakes are great concern.
- The existing buildings constructed before 1981 (this year the new aseismic design law were enforced), are requested to conduct seismic evaluation and retrofit by "The Law for Promotion of Seismic Retrofit of Buildings" in 1995.
- Moreover, seismic evaluation and retrofit for the buildings including condos near the emergency transportation road in the big city like Tokyo have started by the revision of above Promotion Law in 2013 to ensure the escape route safety for evacuees.
- JSCA (Japan Structural Consulting Association) Seismic Evaluation and Retrofit Plan Committee (Chairperson Takayuki Teramoto) conducted certification of seismic evaluation and retrofit of these 646 buildings from 2014 until 2017 fiscal year.
- This paper shows the results of these buildings (including condos) evaluation and retrofit plan and proposal how to promote seismic retrofits of condos, those were not progressing well.

2. Analysis of seismic evaluation results on condos

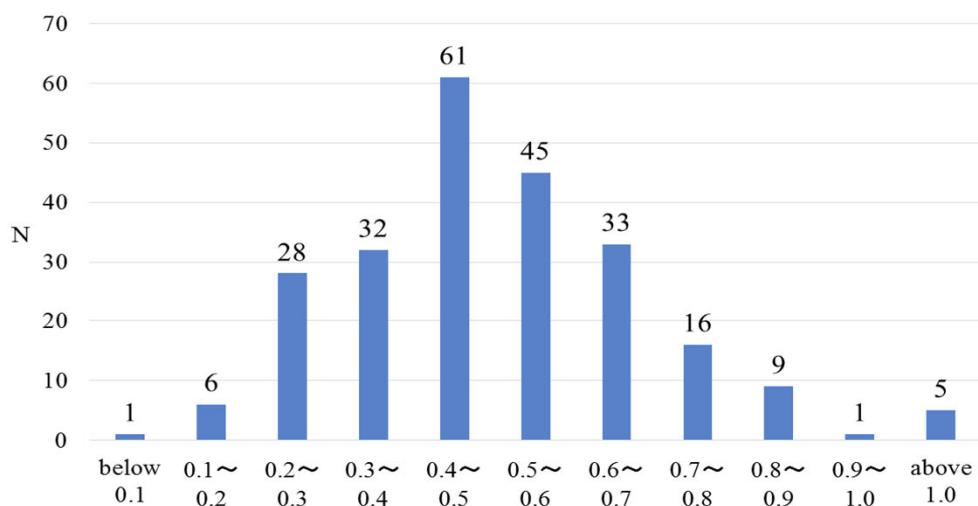


Fig. 1 Smallest Is of check results of 237 condos

$Is = C(\text{strength}) \times F(\text{ductility})$, $Is \geq 0.6$ is safe performance level
 $Is < 0.6$ is unsafe level , Average Is is 0.49.

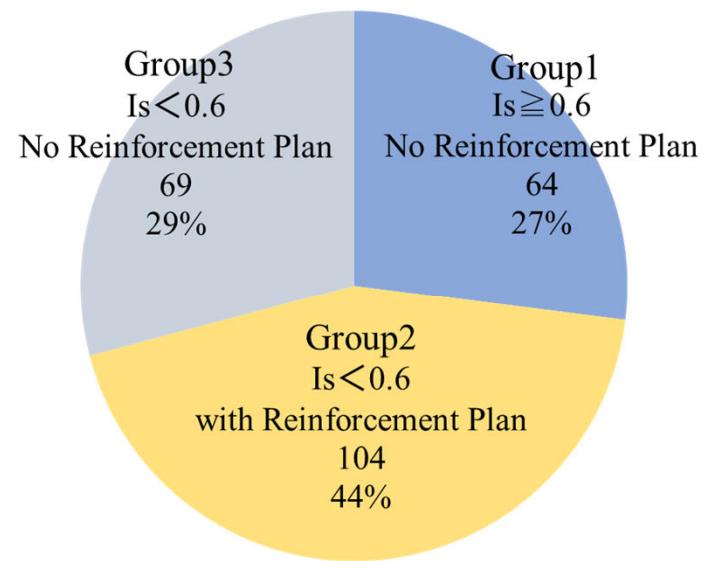


Fig. 2 The ratio of the reinforcement on condos by the result

Group2 + Group3 = 173 condos, 73% of all needs reinforcement

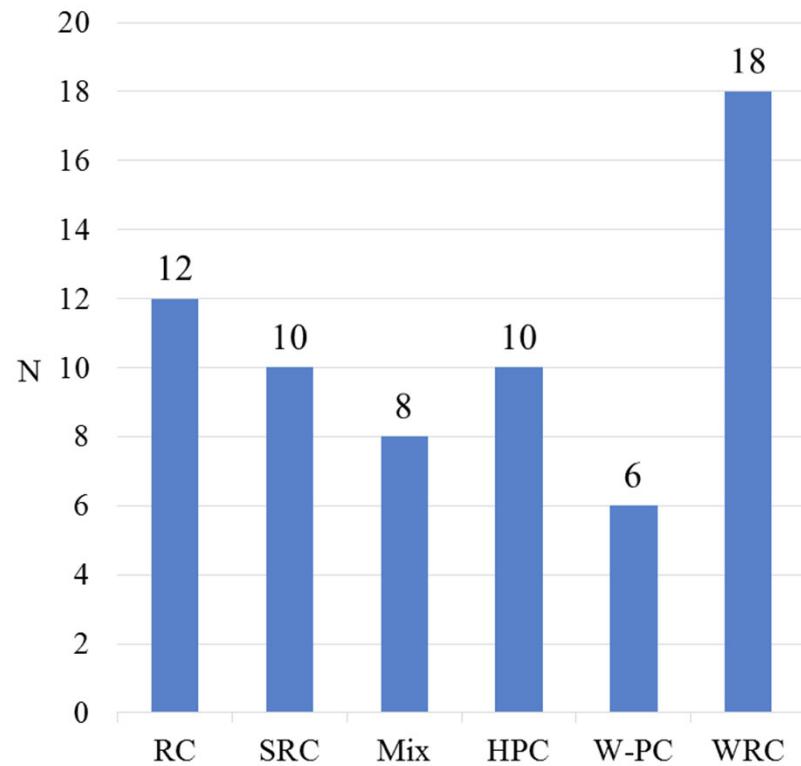


Fig. 3 Structure type classification of non-reinforcement condos, $I_s \geq 0.6$

This shows 64 condos structure type in Group1 (Fig.2)

Mix=SRC+RC structure.

3. Analysis of reinforcement plans in condos.

3-1. The outline of reinforcement target condos

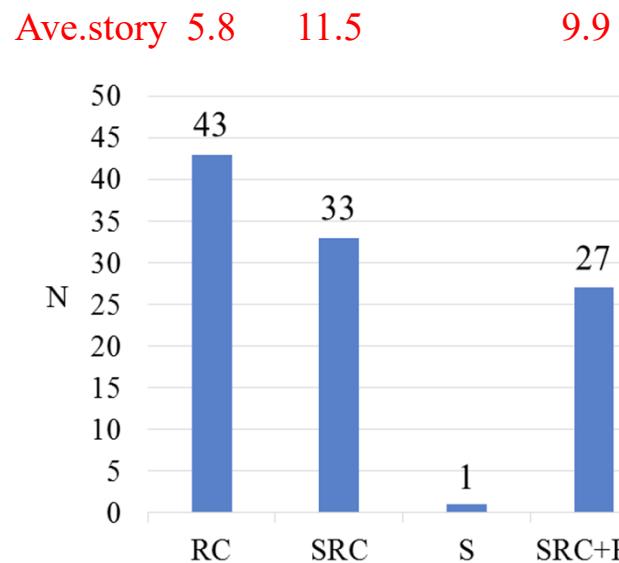


Fig. 4 Structure classification in condos

Total 104 condos in Group2 (Fig.2) ,
SRC+RC means Mixed Structure

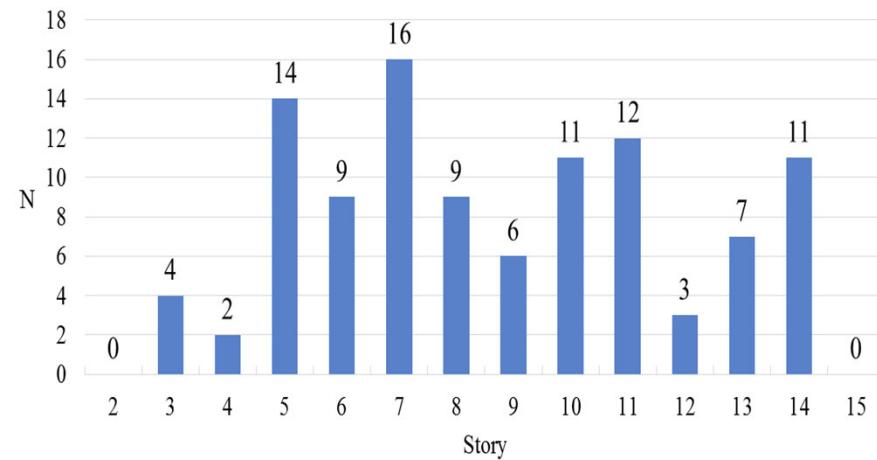


Fig. 5 The number of stories above ground

Over 10 stories condos are 44 buildings,43%. SRC and Mixed

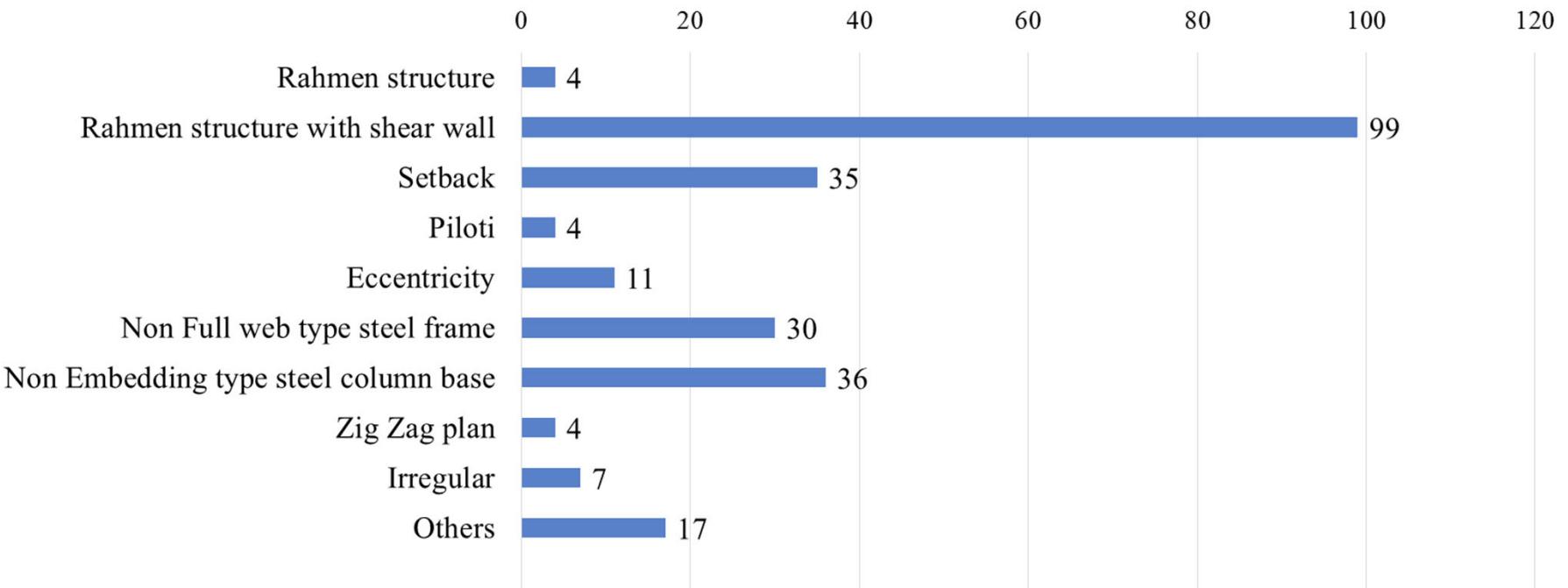


Fig. 6 The structural feature of the reinforcement condos

The ridge direction in condos is rahmen structure with insufficient wall. Therefore Is value is small.

The span direction in condos is rahmen with shear wall structure. Due to a lot of wall, Is value is large.

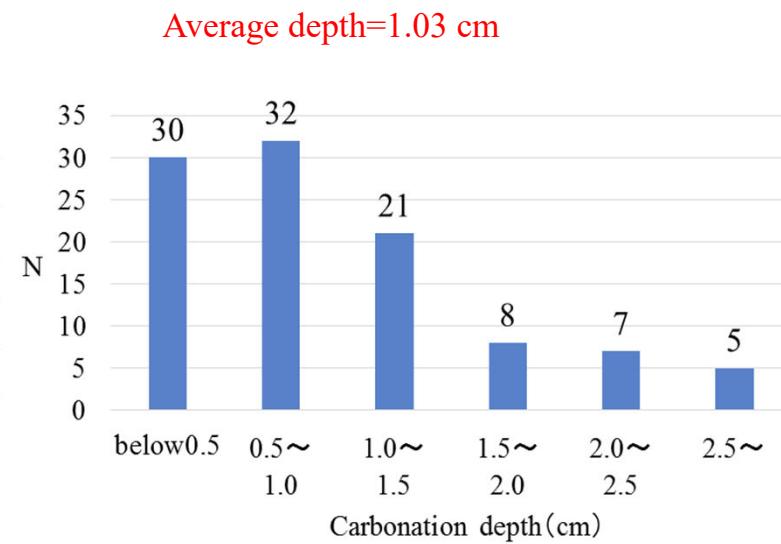
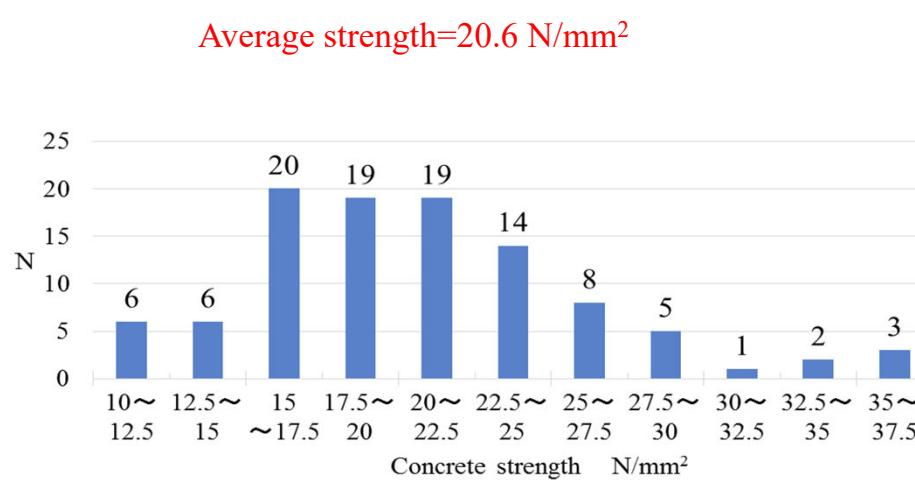


Fig.7 Distribution of min. concrete strength in condos

Low strength concrete is problem!

Fig. 8 Distribution of carbonation depth in condos

Carbonation is not so progressive ,considering 50 years after completion

3-2. Is value and ΔIs

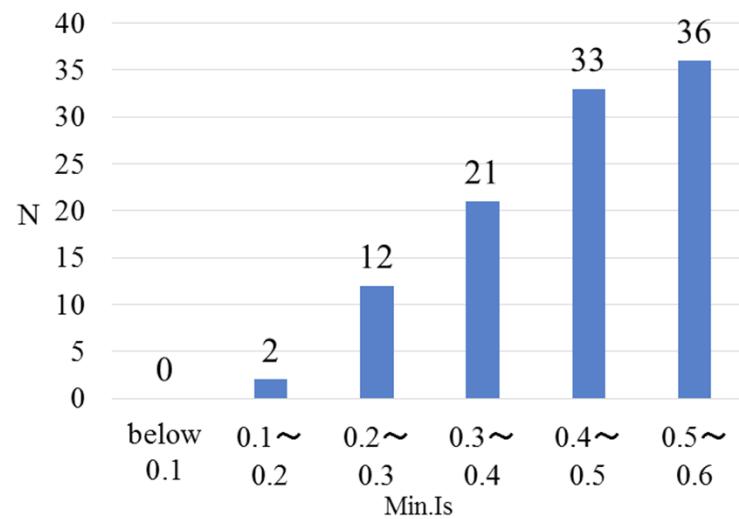
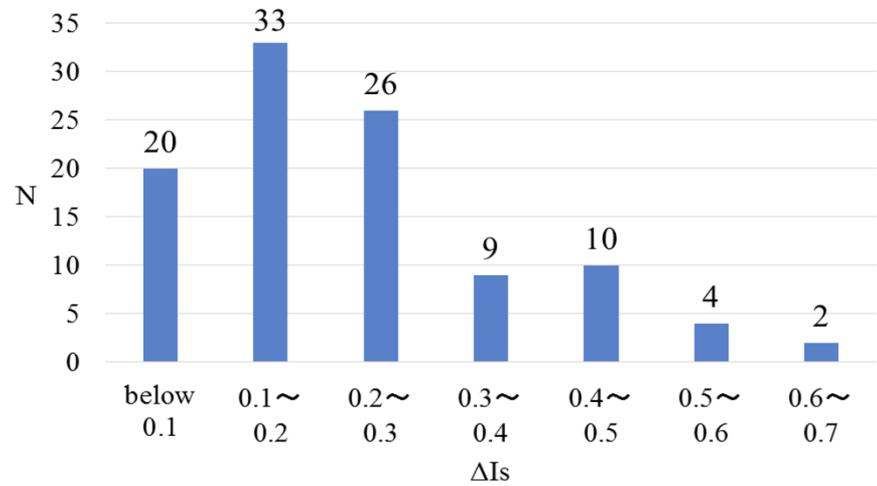


Fig. 9 Smallest Is value by seismic evaluation **Fig. 10 Increased Is value ΔIs by reinforcement**

104 condos with reinforcement plan in Group 2 (Fig.2)



$\Delta Is < 0.3$ is 79 condos, $\Delta Is \geq 0.3$ is 25condos.

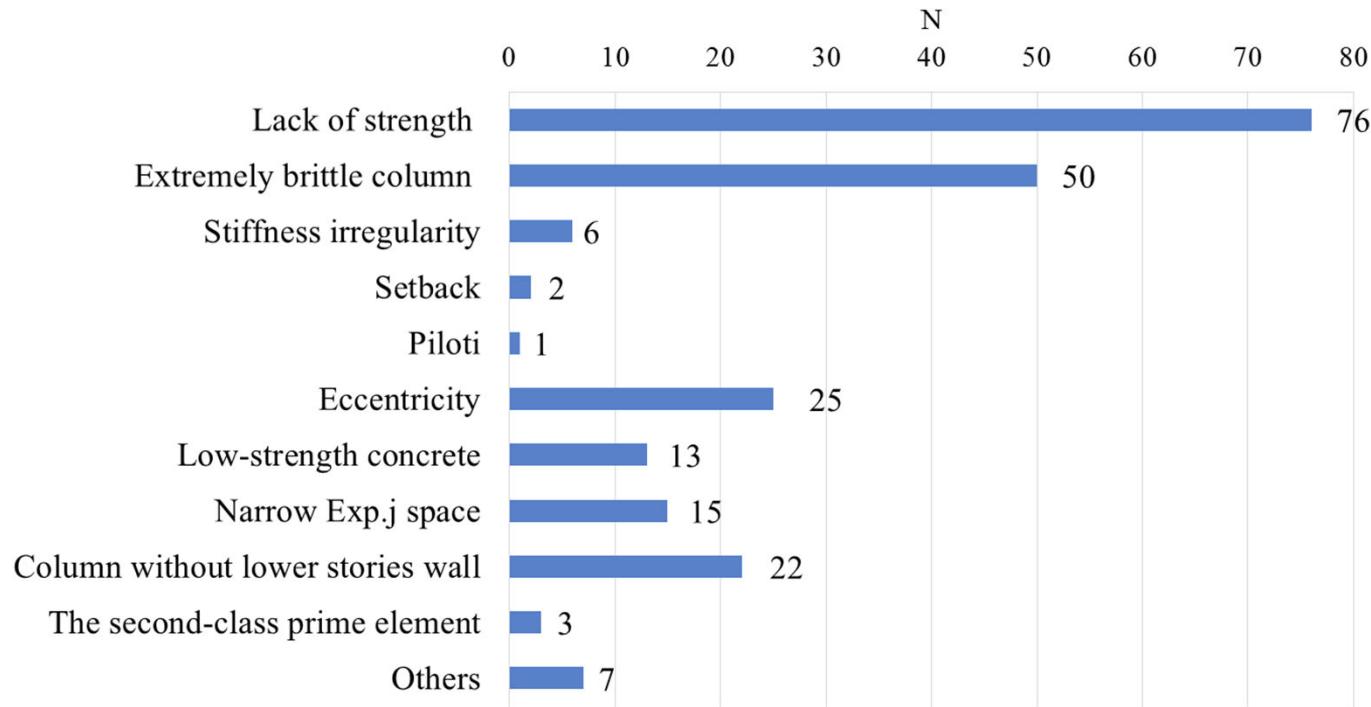
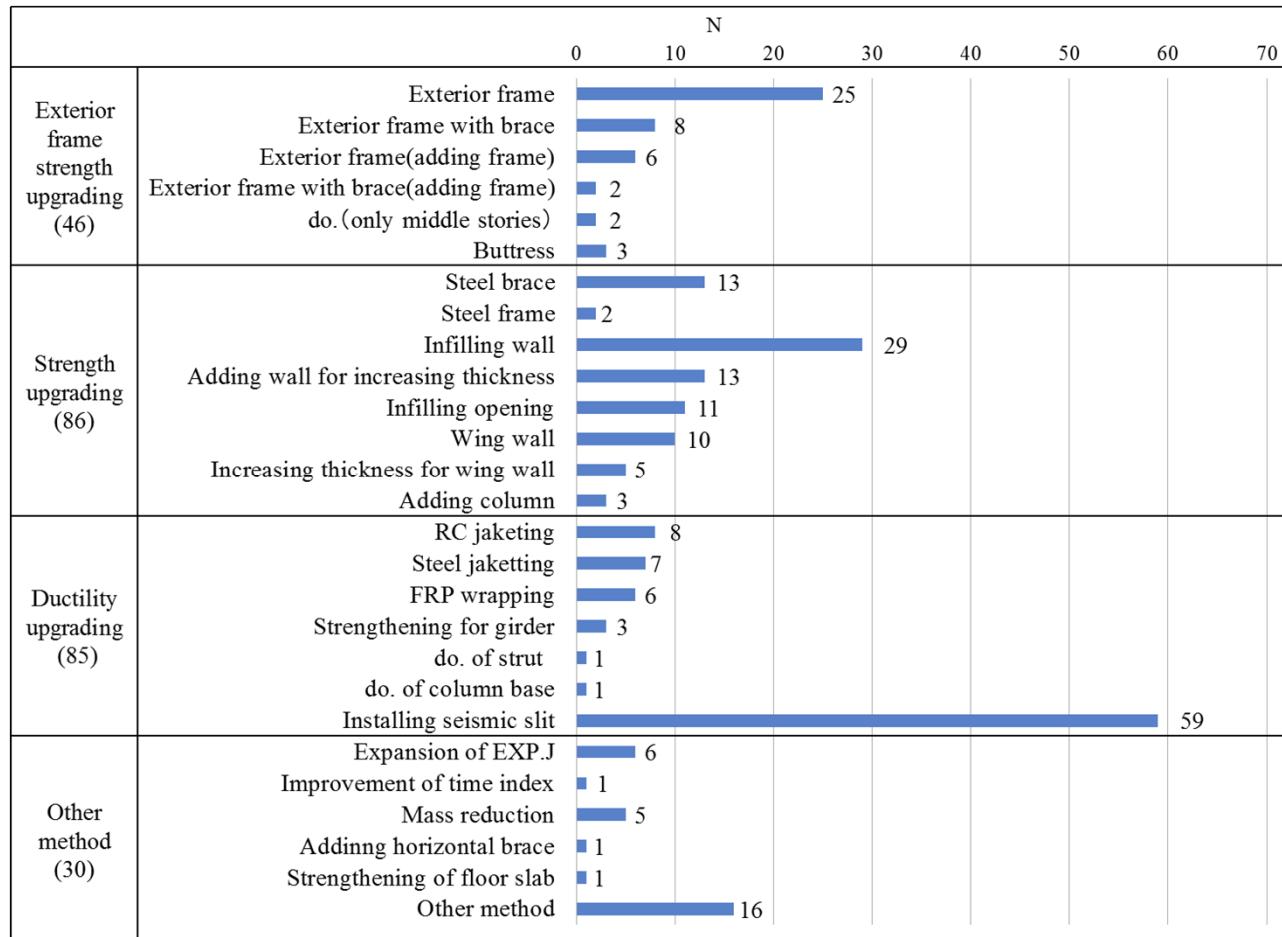


Fig. 11 The structural weak points of condos by seismic evaluation

The ridge direction and the span direction Is value is different because of the difference of shear wall volume.

3-3. Adopted reinforcement method

Table. 1 Kind of adopted reinforcement method



Ditto,略語do.

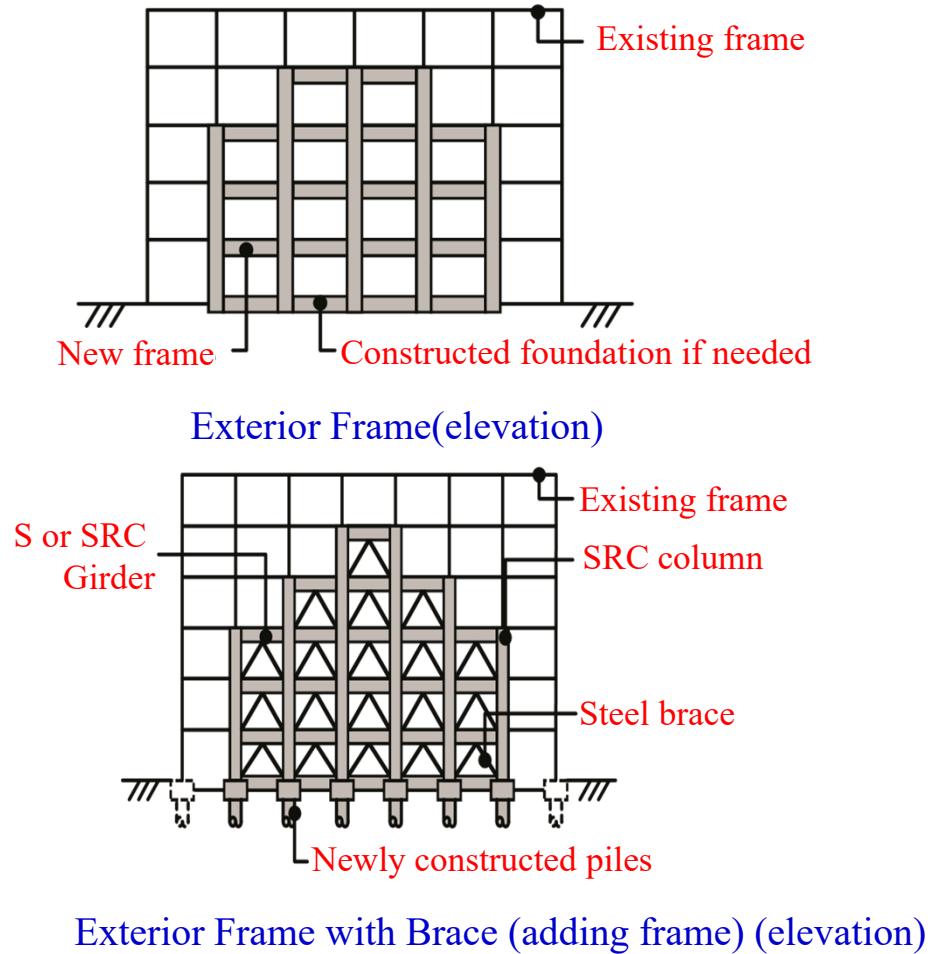
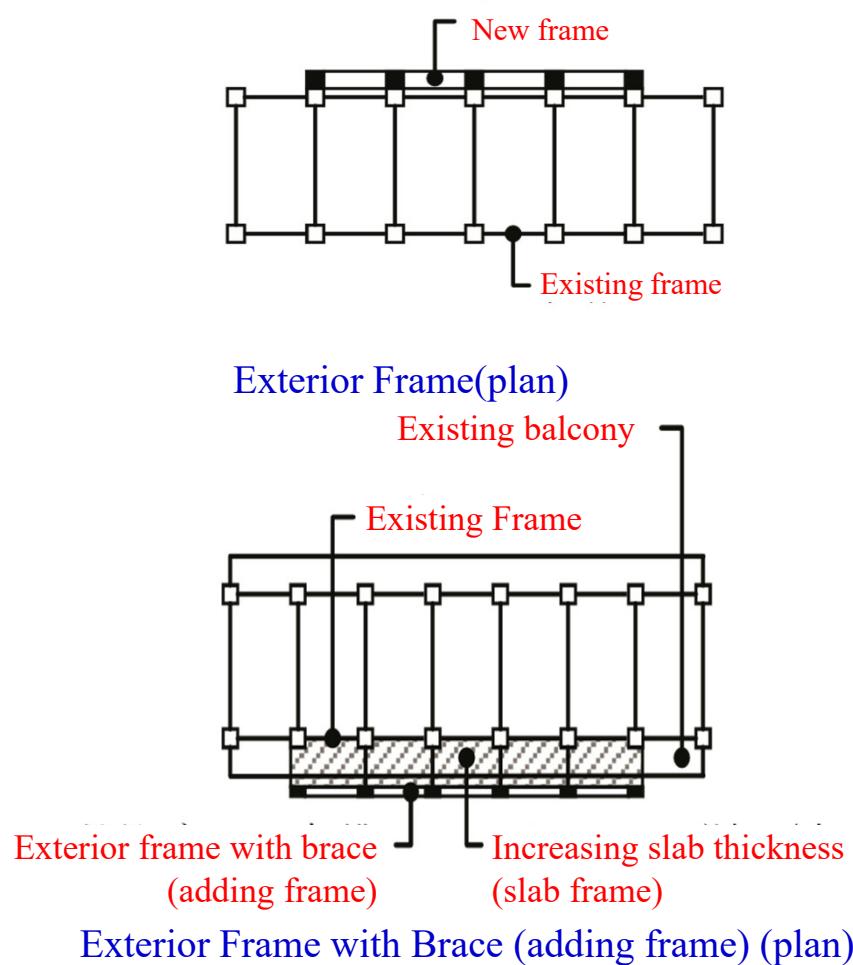


Fig. 12 Exterior Frame and Exterior Frame with Brace (adding frame) (reference 2)

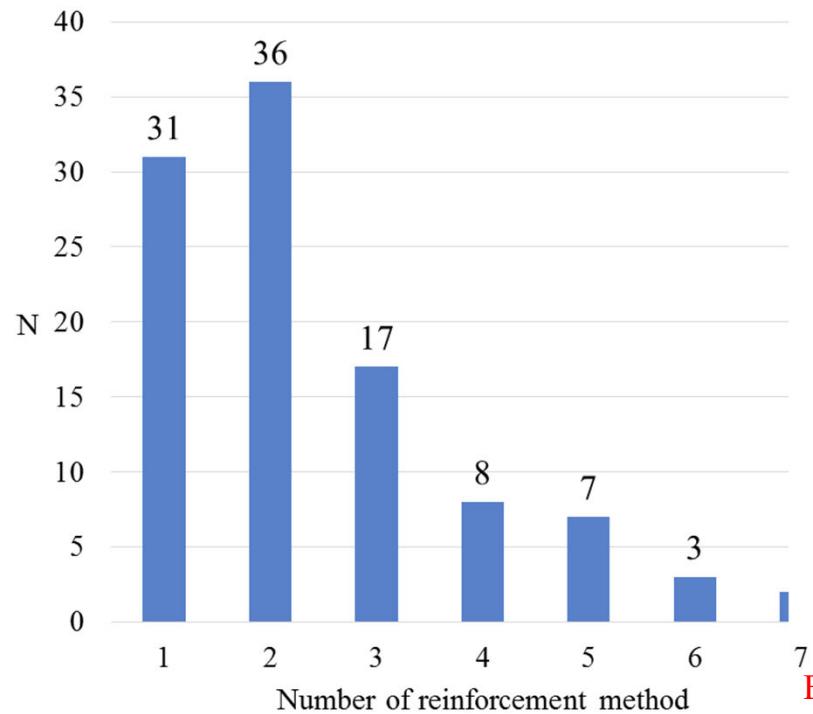
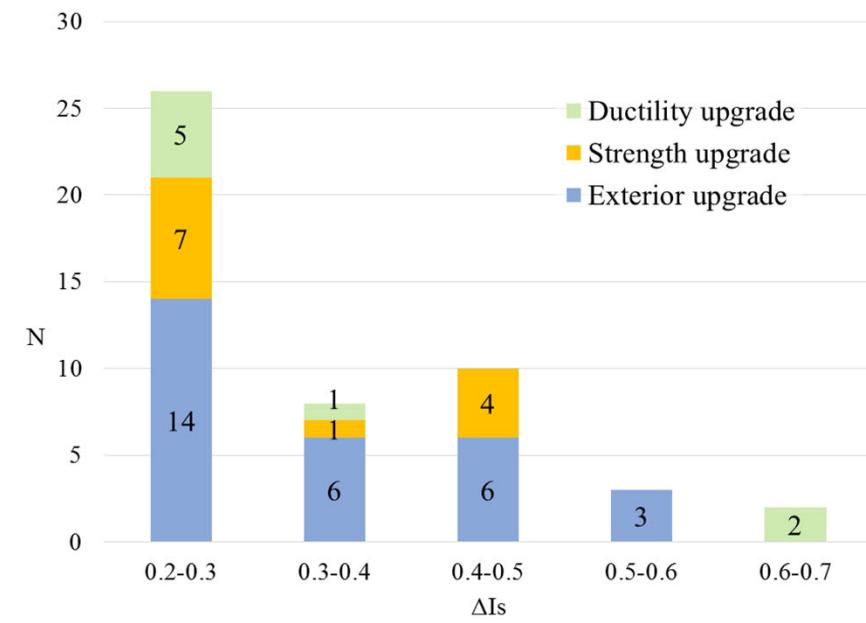


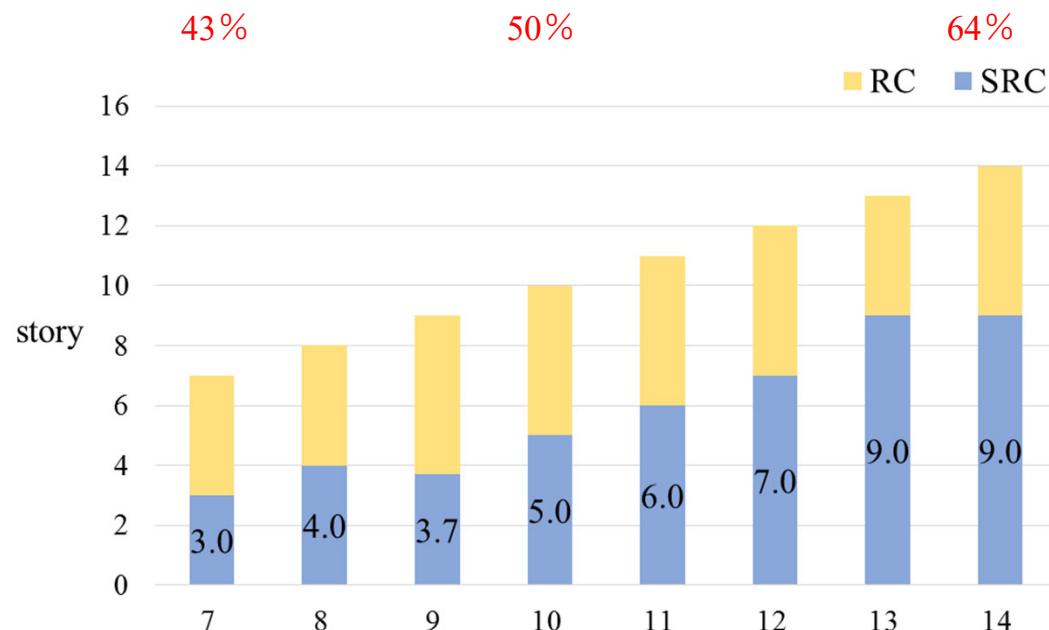
Fig. 13 The number of adopted reinforcement method in one condo.



Exterior upgrading comes to popular by construction while staying

Fig. 14 Reinforcement method used for $\Delta Is \geq 0.2$ condos, 49 buildings.

3-4 The examination of SRC and Mixed structure



Show the Ratio of SRC and RC in mixed structure in terms of height.
Ratio of SRC is getting large with height.

Fig. 15 The number of stories including steel frame in mixed structure

Is values are different in terms of Ridge direction and Span direction and Middle story is minimum.

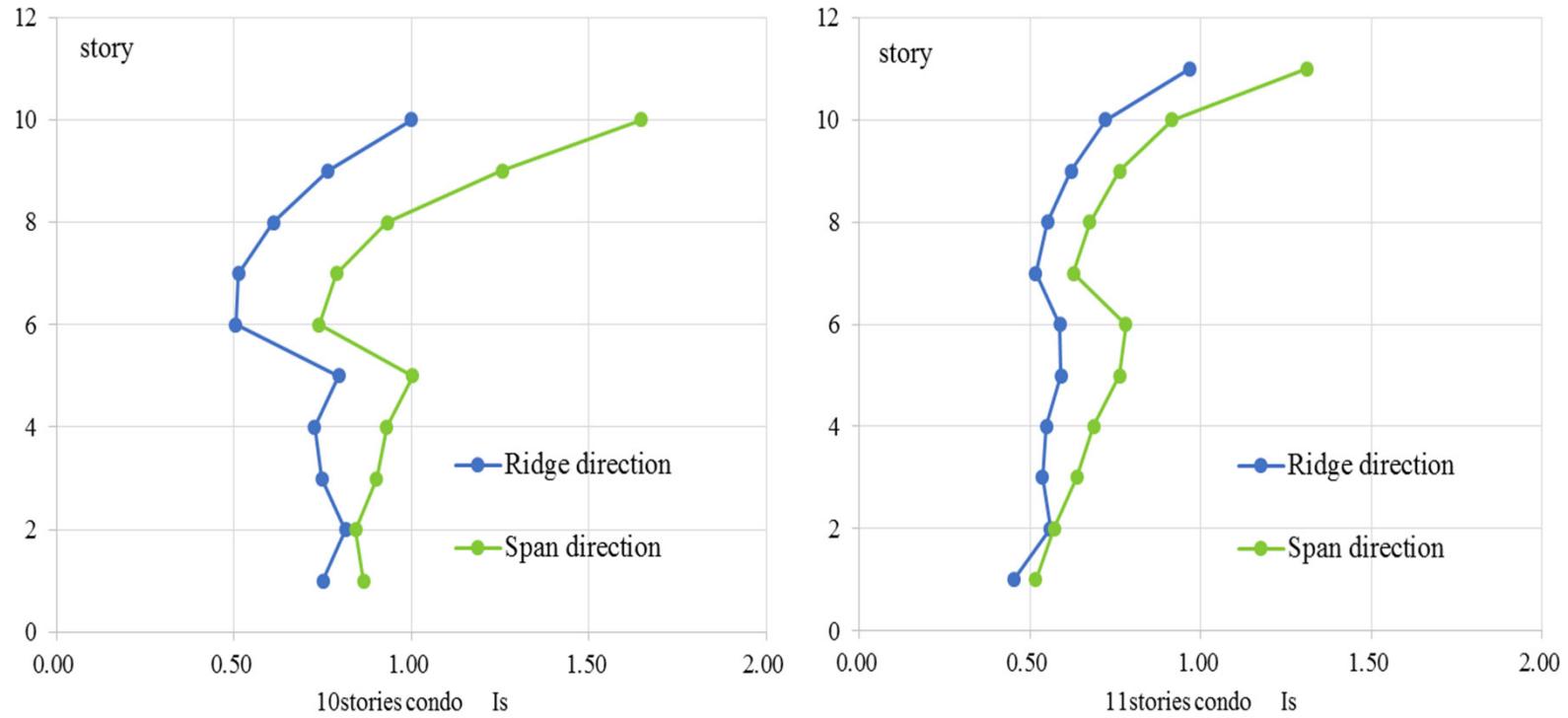


Fig. 16 Mean Is value distribution of the condo along height direction in mixed structure.

Need middle stories reinforcement!! Middle story collapse in Hyogo-ken Nanbu Earthquake is due to this?

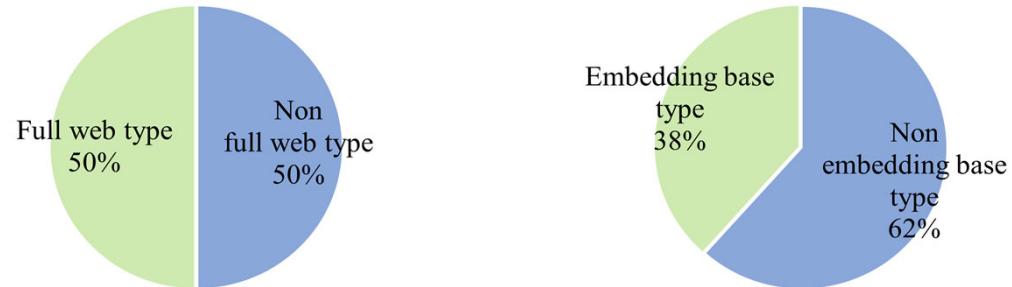


Fig. 17 The ratio of non-full web steel frame and non-embedded column base in SRC and mixed structure.

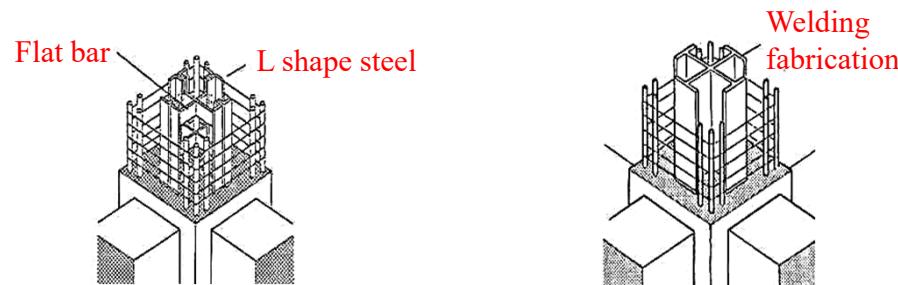


Fig. 18 non-full web steel frame (grid-shaped) and full web steel frame

4. The cause and the measure, why the seismic retrofit in Japanese condos doesn't make progress.

The several causes are considered as follows.

- i) Aging of the resident and the building is progressing, the resident can't afford to pay expensive retrofit cost.
- ii) To form a consensus in condo management society is quite difficult, because it's condominium owner.

The next measures are taken by public administration and structural engineers association, because there is a fear that the next big earthquake would happen soon without aseismic reinforcement in the current state of affairs.

Public administration measure

- i) The expansion of support by local government on seismic retrofit cost.
- ii) The proposition of gradual method on retrofit cost and retrofit method
- iii) The Provision new system to give a continual advice like adviser delegation.

Structural engineer's association proposal

- i) Minimum reinforcement should be done to the part that would bring about fatal damage during earthquake, like collapse.
- ii) The proposition of reinforcement method that is handy and low in cost.

5. Conclusion

(1) Major condos are necessary to conduct seismic retrofit, as a result of the seismic evaluation on condos, however seismic retrofit haven't made progress yet.

(2) The proposed seismic retrofit method are a lot of exterior frame upgrading method because of construction work while staying in residents. But some attention should be paid to anchor strength in low strength concrete.

When I_s value of middle floors is small in mixed structure, it's also necessary to conduct middle floors reinforcement.

(3) To promote seismic retrofit of condos, the expansion of public support funds and the gradual method of reinforcement are necessary. The most important thing is providing new system to encourage resident to make seismic retrofit and give continuous advice to the condos residents all the time.

Lastly, structural engineers have to make effort to reduce the burden i.e. dangerous condo buildings i.e. social negative legacy, for the next generation.