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The study of the method of analysis of a continuous structure constituted different kinds of material. The study of the analytical method based on a development experiment of ISGW by the different kinds of material

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Abstract

In recent years, movements for the utilization of resources have increased, and it is important that we utilize existing architectures as resources. As a result, the attempt has been made that an existing architecture are kept alive longer. As a new system, the hybrid seismic system with different kinds of material is developing. Some of the a materials are glass, plastic, and epoxy resin which have some seismic performances. Interior Shear Grid Wall (=ISGW), which is the new earthquake proofing system, uses those materials. In addition, it is the system that realized seismic reinforcement used for building, That can be designed with a refreshing that it doesn't disturb the environment around it when the building are used usually. However, it is very complicated to analyze the structure. In this paper, I model the analysis of a continuum constituted by different kinds of material based on the experiment result in the development of ISGW. I report a study of the analytical method to keep the analysis model which considered a continuity through different kinds of material.

Keywords: Continuous structure, FEM analysis, quakeproof structure, ISGW

1. Introduction

In late years whenever an earthquake occurs in a country and the area where it occurs frequently, a quakeproof code is revised, and the buildings increase that do not satisfy a code of the quakeproof performance. Therefore immediate correspondence is needed. There are many current seismic reinforcement methods was consisted of the single material such as a steel frame brace and a reinforced concrete wall. Those most have a solid feeling and disturb space. Therefore, the new system that does not disturb of the space can be expected.

The development of the hybrid quakeproof seismic system by the different kinds of material is performed now. This system is that paid its attention to the performance of the material that was unused for a quakeproof element so far such as plastic or the epoxy resin. This system is called ISGW. ISGW constitutes of glass, steel, engineer plastic, epoxy resin as a continuum, and it is a system to resist for an earthquake. In addition, this system is opening-like, and it is the system that realized seismic reinforcement while I use it while there is it. However, there are still few methods to grasp a continuum of the different kind material such as the said article quantitatively.

By this report, the analysis model that paid its attention to a property of provided epoxy resin was analyzed by an experiment result in development of ISGW. This study is of analytical method to grasp a continuous structure model of different kinds of material quantitatively comparing an experiment result with the analysis result and considering it.

Figure 1: Setting situation example of ISGW

2. Examination of the analytical method by the experiment result

2.1. Constitution of ISGW

ISGW is the hybrid quakeproof system that put glass, steel, epoxy resin, and plastic together. This system is fixed to the skeleton of the reinforced concrete structure by epoxy resin. It puts each performance together, and it is a hybrid quakeproof system to resist for an earthquake as one continuous structure. In addition, there is a buffer material preventing direct contact between glass and the steel, and it is the structure that only compression transmits.

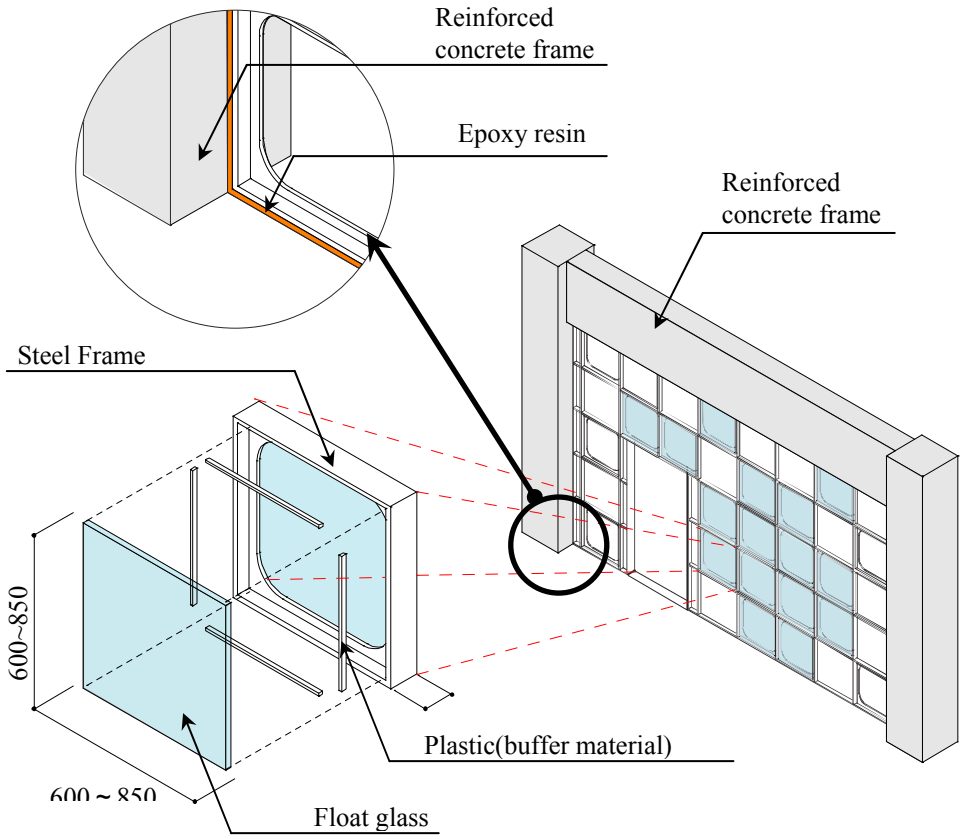

Figure 2: Constitution of ISGW

2.2. Summary of the experiment

Test model was a half scale of the real size. The experiment was used two kinds of earthquakes direction of one side and both sides. Test model was used that arranged a steel panel in a diamond. The height of concrete frame is 2000 millimeters, and the span of it is 2850 millimeters.

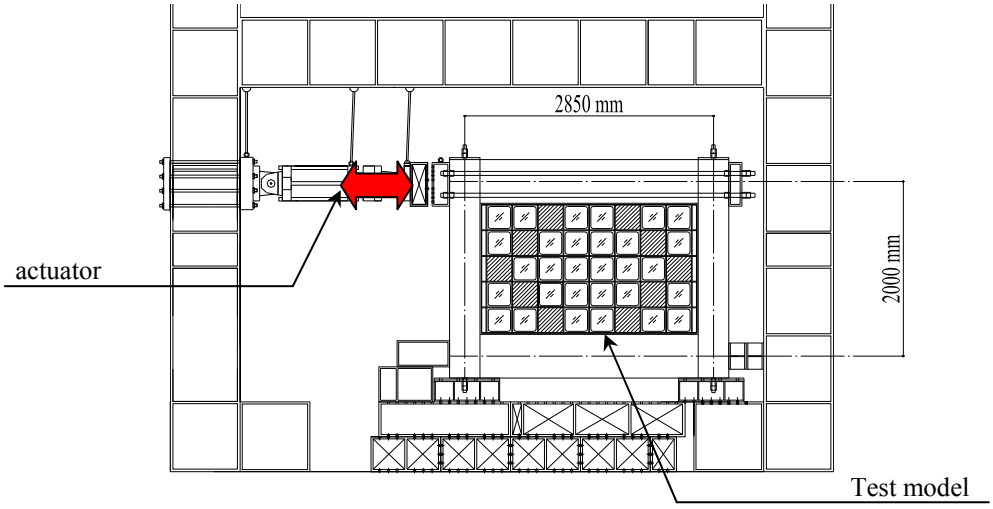

Figure 3: Test model setting situation

Figure 4: Test model experiment situation

2.3. Experiment result

Figure 5 shows P-δ curve of experiment. Test model experimented on 4 in total. The experiment result is the following contents. ISGW shows trilinear model with three phases of stiffness corresponding to the detachment of the epoxy resin. The first stiffness is to story drift 1/2,000. There is not the detachment in epoxy resin and an interface of the concrete and shows elastic behavior. The second stiffness is to story drift 1/750. There is the detachment in epoxy resin of the beam surface. The third stiffness is to story drift 1/250. There is the detachment in epoxy resin of the concrete surface. The epoxy resin after the detachment transmits only compression force. Until story drift 1/250, the load for this system did not suddenly fall and maintained a proof stress. Steel did not yield at the time of story drift 1/750. It yielded partially at the time of story drift 1/500 when the transformation of it increased. In addition, it was confirmed that the stiffness deteriorated as follows. The second stiffness was the result that about 29% was low of the first stiffness. The third stiffness was the result that about 56% was low of the second stiffness. The third stiffness was the result that about 69% was low of the first stiffness.

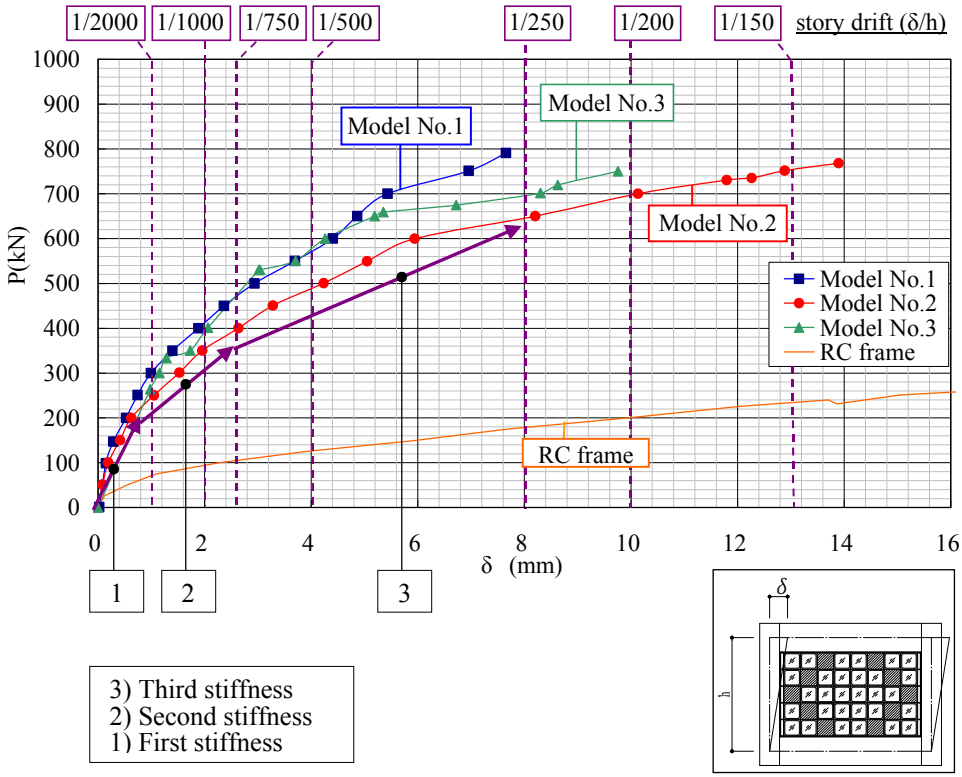

Figure 5: P-δ curve of experiment

3. Analysis based on the experiment result

3.1. Analytical condition

It was analyzed by finite element method (FEM). The analytical program used "MSC/NASTRAN". Figure 6 shows an analytical model. It was modeled in shell elements of the same size as a half scale model used the experiment. This system is used material showing non-linear behavior such as epoxy resin or the plastic. Therefore, I perform the non-linear analysis that considered material's characteristic of each one. The load is divided it into a horizontal direction and is inputted two load points.

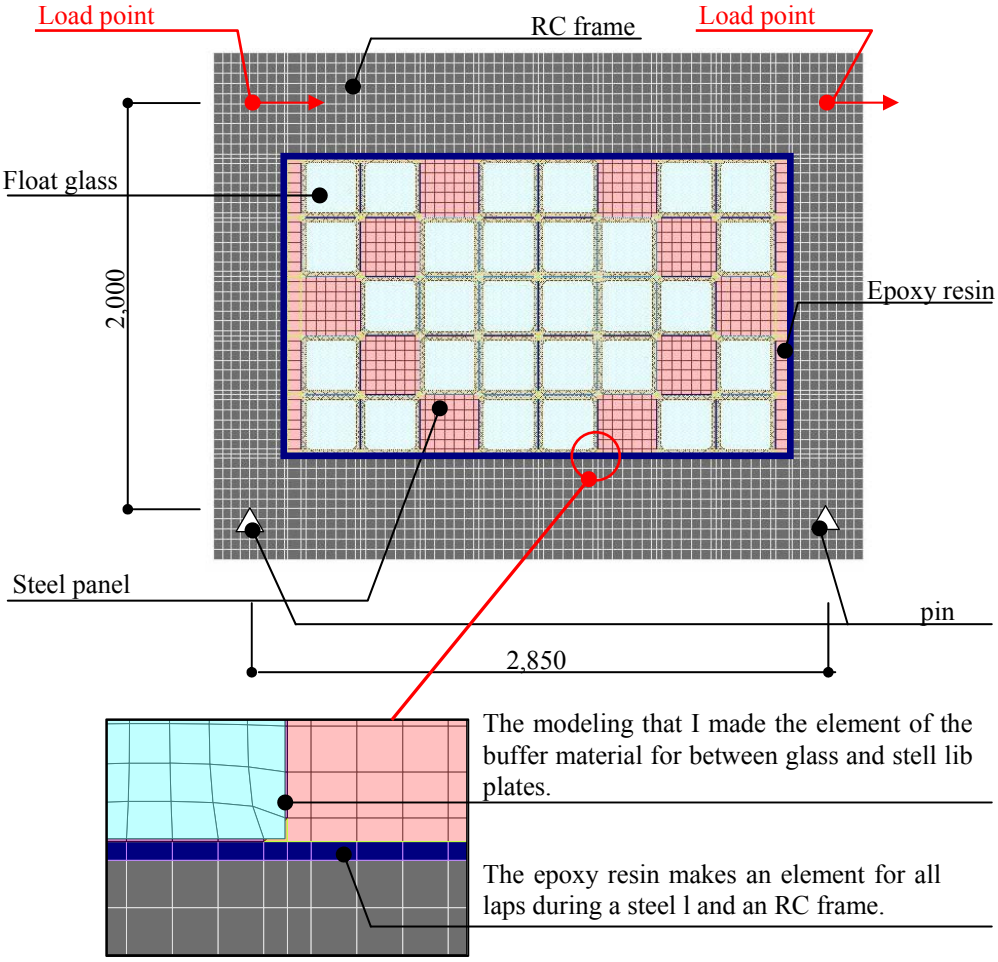

Figure 6: Analytical model

3.2. Analytical method based on an experiment

This system repeats the preliminary analysis that accepted the detachment state of the epoxy resin from an experiment and analysis it. According to the result of the preliminary analysis, it can be classified in the analysis model of three phases of states to show as follow.

3.2.1.Analysis model without the detachment of the epoxy resin

The analysis model that is in a state that it is an analysis model showing the elastic behavior that assumed story drift 1/2000, and there is not the detachment of the epoxy resin. This model is called "First stiffness model". The epoxy resin of the concrete surface models it as a coherence state. (Figure 7)

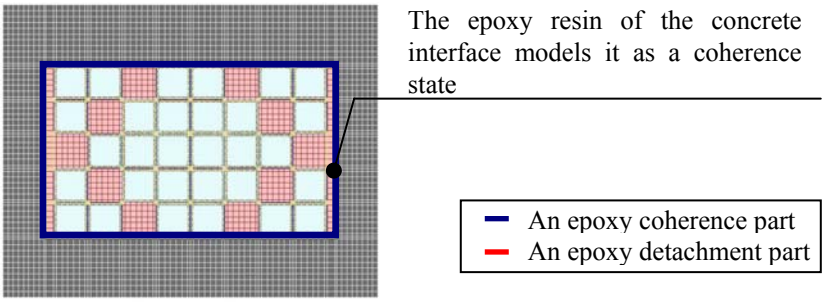

Figure 7: Analytical model to story drift 1/2,000

3.2.2. Analysis model has the detachment of the epoxy resin of the beam surface

The analysis model is assumed story drift 1/750. This model is called "Second stiffness model". It is that the epoxy resin assumed detachment of the beam surface. The epoxy resin of the beam surface models only a part transmitting compression force. (Figure 8)

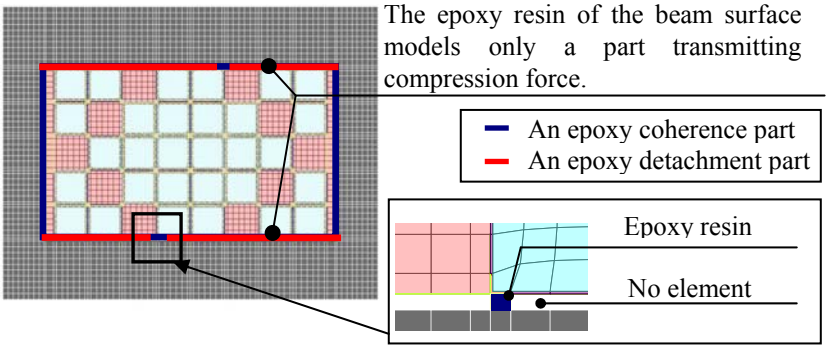

Figure 8: Analytical model to story drift 1/750

3.2.3 Analysis model has the detachment of the epoxy resin of the concrete surface.

The analysis model is assumed story drift 1/250. This model is called "Third stiffness model". It is that epoxy resin assumed detachment of the concrete surface. The epoxy resin of the concrete surface models only a part transmitting compression force. The epoxy resin except parts of one dose not model it. (Figure 9)

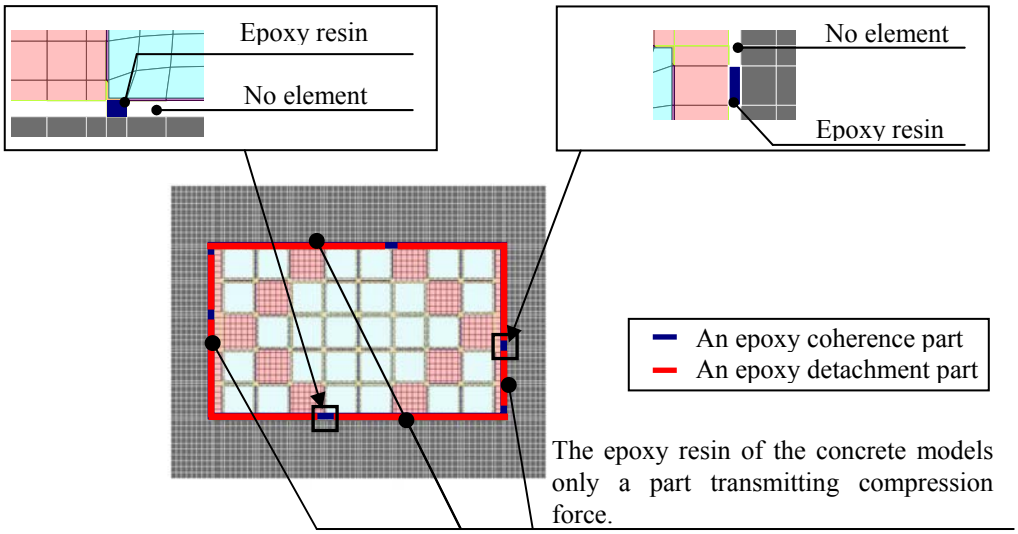

Figure 9: Analytical model to story drift 1/250

3.3. Analysis result

Figure 10 shows P-δ curve of analysis. By three phases of analysis models, the curve of three kinds of stiffness was provided. It was confirmed that stiffness deteriorated in the analysis by this by the detachment of the epoxy resin. The second stiffness was the result that about 34% was low of the first stiffness. The third stiffness was the result that about 60% was low of the second stiffness. The third stiffness was the result that about 73% was low of the first stiffness. This is approximately equal with a rate of decline of the stiffness of the experiment result.

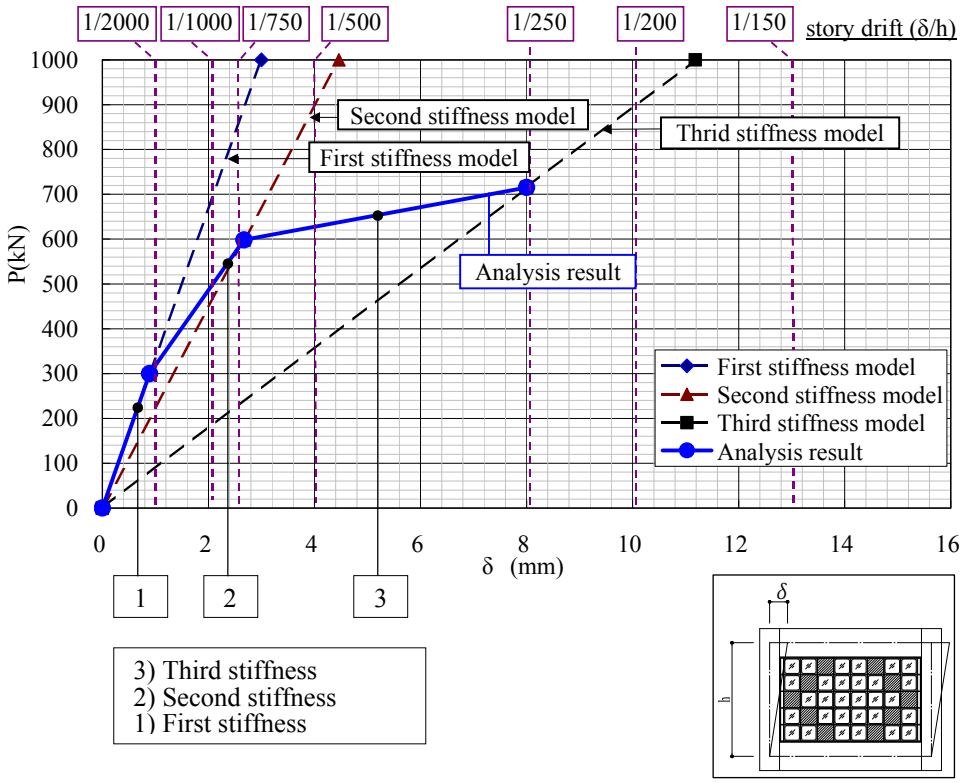

Figure 10: P-δ curve of analysis

3.4. Comparison of the experiment and the analysis

Figure 11 shows P-δ curve compared an experiment with analysis. In the first stiffness, the analysis was approximately equal stiffness of the experiment. In the second stiffness, it was the stiffness that 20% bigger than an experiment. In the third stiffness, it was approximately equal stiffness of the experiment. In the second stiffness, it followed that an analysis was higher than an experiment result, but it was able to confirm that it was equal stiffness of the experiment.

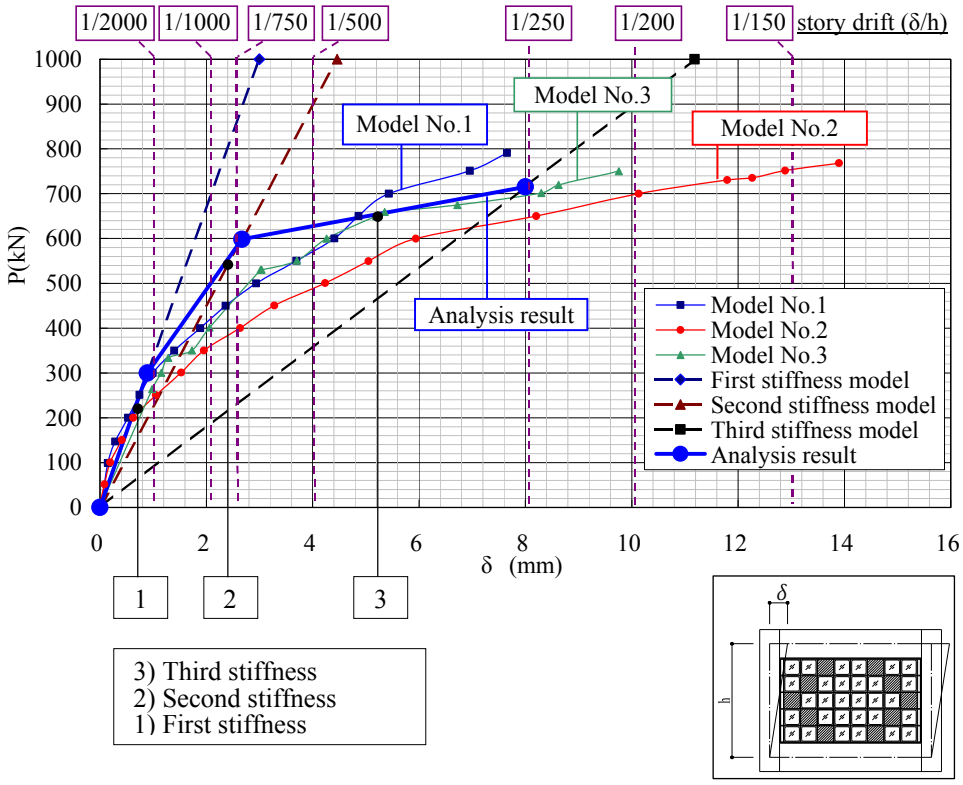

Figure 11: P-δ curve of experiment and analysis

4. Consideration and conclusion

From the experiment result, P-δ curve of ISGW understood that it has three phases of stiffness by the detachment of the epoxy resin. So this study made the analysis model that assumed the detachment of three phases of epoxy resin. As for the analysis result that these analysis models used, it was confirmed that it was an experiment result and approximately equal stiffness and it was approximately equal performance. It is thought that this method of analysis has validity, further more using this model which has the detachment state of the epoxy resin, provides one of the analytical methods, for continuous structure, such as the concrete and steel.

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