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Numerical Analysis for Development of Vertical Falling Prevention System

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Abstract : Various falling prevention systems with vertical guided rail have been supplied in order to prevent falling accidents and acquire the long life and cost down for the maintenance. Almost the imported system is composed of a guided rail and the comfort components. It has the mechanism that cannot be dismounted from the guided rail at the accident site. Thus, the aim of this study is to develop a falling prevent system that has a direct dismounting function, which can release easily from the falling accident point. This system has a high durability and robust. And the cost efficiency of the system and safety for workers also are improved remarkably. From the results, we showed the proposed new falling system is sufficiently safety and satisfies the KOSHA regulation through the numerical stress analysis. Also it is expected as the useful and effective safety device for workers.

Key words: falling prevention system, comfort, guided rail, numerical analysis, dismount

1. Introduction

Recently, the falling accidents have increased in the structure and heavy industries [1]. Various falling prevention systems with vertical guided rail have been supplied in order to prevent falling accidents because it gives the long life and cost down for the maintenance [2]. However there are not the reliable and domestic the falling prevention system until now. Almost systems were imported from U.S.A, Japan, England and France. It brings about flowing the enormous money out of country. Furthermore, the imported system consists of a guided rail of a rigid body and the comfort and trolley components. When workers climbed the ladder with a falling prevention system, this has a mechanism that can not be released from the guided rail even though they want to release from the rail for an emergency. A worker can escape from the rail after arriving at the top or bottom. It prohibits the rapid escape from the guide rail. That situation can cause the fatal injury of falling workers. And this mechanism is so inconvenient for efficient working. Thus, the aim of this study is to develop a falling prevention system that has a direct dismounting function, which can be released easily from the stop point. This system has a high durability and robust. And the cost efficiency of the system and safety for workers also will be improved remarkably.

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2. Numerical Analysis

2.1 Guided rail numerical analysis model

The rail material assumed in this analysis are aluminum 6061-T6. Table 1 shows mechanical properties of the material.

The rail with latch is modeled in considering boundary conditions with symmetry. Fig. 1 shows the configuration of a finite element model of the guided rail. The total number of elements and nodes are 125730 and

Table 1. Mechanical properties of the Al 6061-T6[3]

Material	Elastic Modulus (GPa)	Yield Strength (MPa)	Ultimate Strength (MPa)	Poisson's ratio
Al6061-T6	69	276	310	0.3

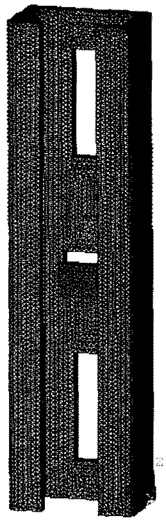

Fig. 1. The finite element model for the rail.

199745, respectively. The falling impact on the rail is supposed to give impact forces which happen by a free drop with 1 m height and 100 kgf weight considering the distance of a rope length and a latch of the rail. The load condition was given when the workers with 100 kgf weight dropped down freely. The analysis was conducted within elastic condition. Also the load 8.2 kPa was impacted on the latch of the rail.

2.2 The numerical analysis method for the comfort

The analyses were conducted for two kinds of comforts. One is conventional imported comfort type(Comfort-1) and other is the developed new comfort type (Comfort-2). The workers can escape directly from the rail by taking the comfort-2 off when the worker meets the emergency. Here the method of taking the comfort part off from the rail is omitted because of the company's relationship. The specific contents and method can be reported by a direct contact. Two type comforts were compared about the stress and displacement fields. The used finite element analysis program was FEM software ANSYS9.0 code [4]. Table 2 shows FEM model specification for Comfort-1. The material was STS-316L and elastic modulus was 198 GPa. Numbers of element mesh and node were 123014 and 187741 each other.

Fig. 2 shows Comfort-1 model and mesh element configuration. Only the parts that transfer the load on

Table 2. Comfort-1 analysis model specification

element	node	Elastic Modulus	Poisson's ratio
123014	187741	198 GPa	0.3

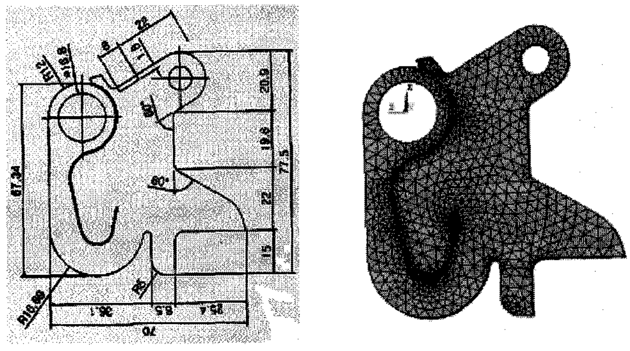

Fig. 2. Comfort-1 model and element configuration.

the rail contacting with a comfort were modeled for the numerical analysis. The cover of comfort moving up and down along the rail was omitted from the analysis model.

At the first time, the analysis was conducted by non-linear condition because the material properties have elastoplastic behavior. However the maximum stress was under the yield stress. Then the numerical analysis was done within an elastic domain. The impact load on the latch and hook of the comfort-1 was given by 8.27 kPa.

Table 3 shows the new type comfort (Comfort-2) model. Also the mechanical properties and finite element and node numbers were expressed on the Table 3. The material was the same STS-316L with Comfort-1 type. And the analysis was done as like Comfort-1. Only the parts that transfer the load on the rail contacting with a comfort-2 were modeled as like Comfort-1

Table 3. Comfort-2 analysis model specification.

element	node	Elastic Modulus	Poisson's ratio
34881	54545	198 GPa	0.3

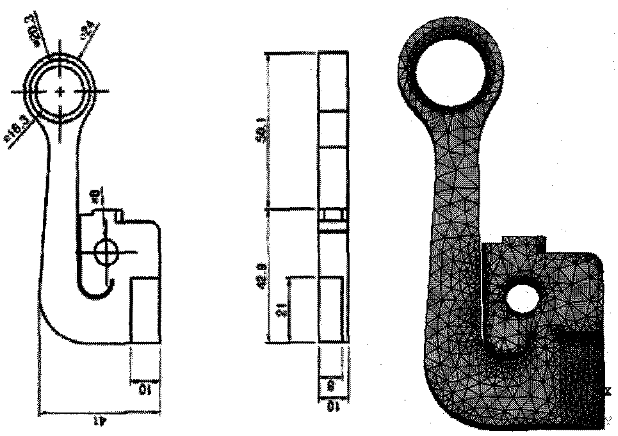

Fig. 3. Comfort-2 model and elements configuration.

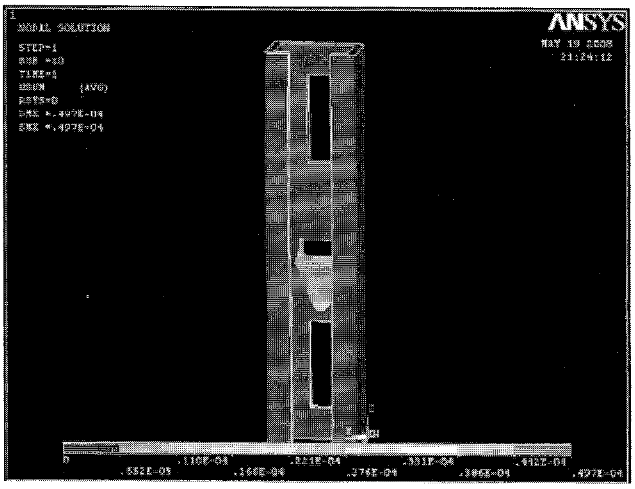

Fig. 4. The displacement contour of the guided rail.

type. The impact load on the latch and hook of the new comfort-2 was also given by 8.27 kPa.

3. Results and discuss

3.1 Guided rail displacement evaluation

Fig. 4 shows the displacement contour for the rail impacted by the comfort latch. The maximum displacement was 0.00497 m for the free falling condition with 100 kgf weight and 4 m height. The value of 4.97 mm is less than 1/10 of the original latch height. Thus, the structural safety was satisfied sufficiently.

3.2 Results of Comfort-1

Fig. 5 shows the displacement contour of Comfort-1 by loading the impact. The comfort-1 has two parts. One strikes the rail and another part connects with the rope. In Fig. 5, the blue contour area has no displacement because its material strength is strong sufficiently even though its part was impacted by the rail. The ring part connected with the rope is loaded by the rope. The maximum displacement was occurred at the point that contact with the rope. This value was decreased along the down direction. The maximum displacement was 0.34 mm. It is satisfying small displacement amount to require the safety condition.

3.3 Results of Comfort-2

Fig. 6 shows the displacement contour of the new developed Comfort-2 loading the impact. The comfort-2 has also two parts. One strikes the rail and another part connects with the rope. In Fig. 6, the blue contour area expresses no displacement because its material strength is strong sufficiently even though its part was impacted by the rail. The maximum displacement was occurred at

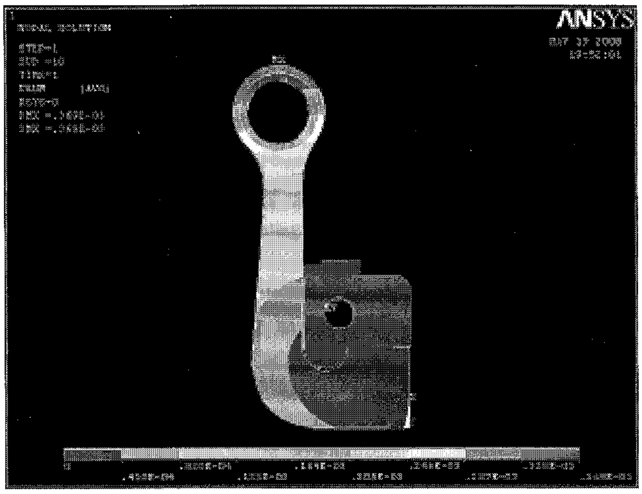

Fig. 6. Displacement contour of Comfort-2.

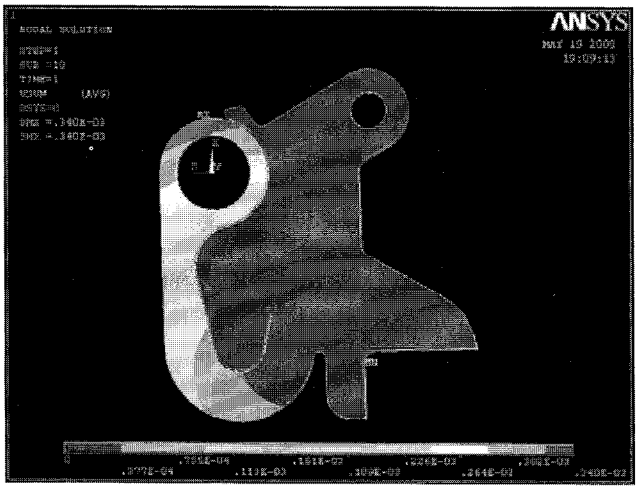

Fig. 5. Displacement contour of Comfort-1.

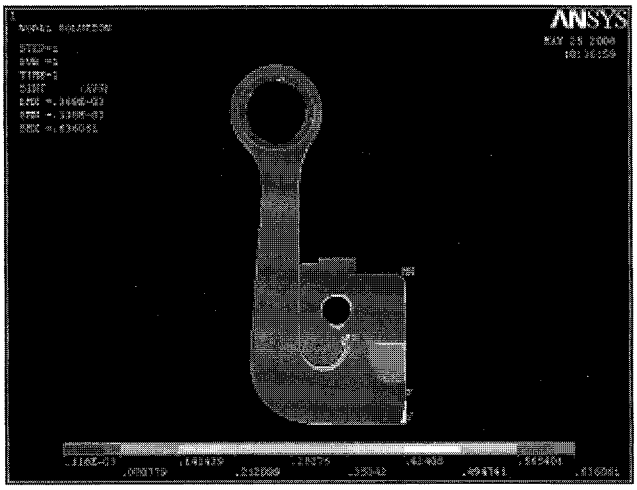

Fig. 7. Stress contour of Comfort-2.

the ring point that contact with the rope. This value was decreased along the down direction. The maximum displacement was 0.396 mm. This value is a little greater than Comfort-1 type. However, it is also satisfying small displacement amount to require the safety condition. Even if the comfort part excesses the deformation criterion, the only comfort part can be exchange with new items and the blue color part contacting on the rail continues to use without the exchange.

Fig. 7 shows the stress contour of comfort-2 type we developed. The result is stress for the one third of real loading condition of the impact loading. The maximum von Mises stress is obtained by 0.636 MPa. This is very small value in comparison with the yield strength 370 MPa. Even though on the real accident condition that a worker with weight 100 kgf falls at the height 4m, the Comfort-2 will endure the falling impact loading. Thus new developed Comfort-2 satisfies the safety condition.

3.4 Loading performance test

The new developed Comfort-2 should be passed the KOSHA performance requirement [5]. Fig. 8 shows the static and dynamic performance test results. The static test(Fig. 8(a)) was accomplished by keeping 15 kN during 3 minutes on the combined the falling system and the guided rail. The Comfort-2 kept in a stable condition. The Fig. 8(b) shows the dynamic test. The maximum transferred impact force was 5.026 kN. This satisfies the KOSHA regulation.

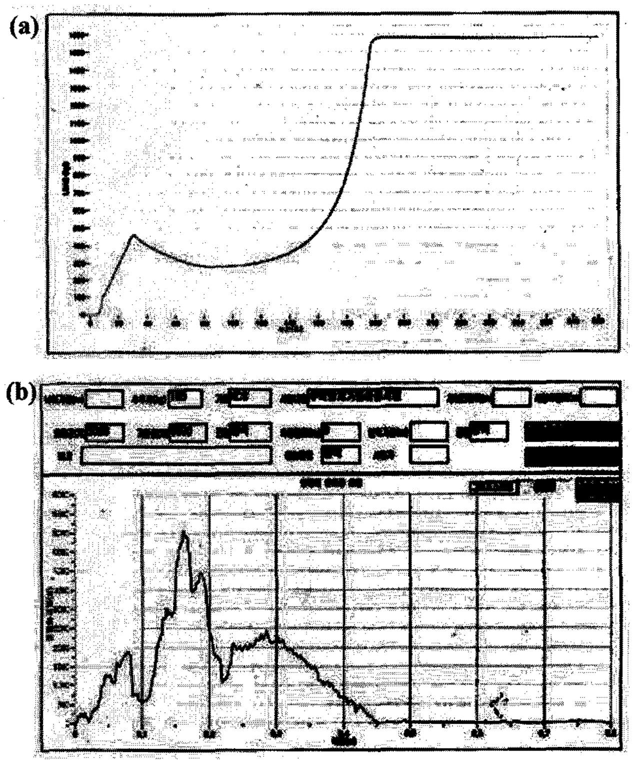

Fig. 8. (a)The static performance test. (b)The dynamic performance test.

4. Conclusions

In this work, the rigid guided rail type falling system was proposed by introducing a new Comfort with emergency escaping mechanism. And the numerical analysis for the new comfort type falling system was accomplished to investigate the safety of the comfort. The results are as follows below.

(1) The new comfort type has developed a mechanism taking the rail off easily from which the worker wants to dismount.

(2) The maximum displacement of the rail was 4.97 mm under the free falling condition with 100 kgf weight and 4m height.

(3) The maximum displacement 0.396 mm of the new comfort was occurred at the ring point that contacts with the rope. And the maximum von Mises stress was obtained by 0.636 MPa. This is very small value in comparison with the yield strength 370 MPa. Thus new developed Comfort-2 satisfied the safety condition.

(4) The static load and dynamic impact force performance for the proposed falling prevention system satisfied the KOSHA regulation requirement.

Acknowledgement

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