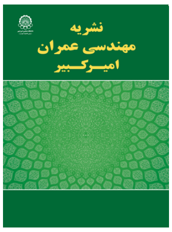

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Dynamic Behavior of Composite Floor Consisting Profiled Steel Sheet and Dry Board under Explosion Load

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ABSTRACT: One of the kinds of structural floor systems is consisting of profiled steel sheet and dry board which is connected by self-drilling and self-tapping screws. This research aims to study the behavior of mentioned floor under explosion load. For this purpose, effects of various parameters such as the thickness of the dry board and profiled steel sheet, kind of dry board, screw spacing, boundary conditions, floor dimensions, using of double profiled steel sheet and dry board, and also weight and distance of explosive material from the center of the floor, on the nonlinear dynamic behavior of the mentioned floor are studied. This study was performed by using the numerical finite element method taking advantage of ABAQUS software. The research results showed by varying parameters such as thickness and kind of dry board, dimensions and boundary conditions of the floor, using of double profiled steel sheet and dry board, and also distance and weight of explosive materials, significant changes are created in maximum displacement and strain energy of floor. But, varying other above-mentioned parameters did not create important changes in them. The profiled steel sheet and dry board reached their yield stresses under various conditions, though in many conditions they did not reach their yield stresses. The results of current research present great help to researchers and designers in identification effective and ineffective parameters on the behavior of studied floor under explosion load.

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1. INTRODUCTION

One of the structural composite floor systems is consisting of profiled steel sheet (PSS) and dry board (DB) which are connected by self-drilling and self-tapping screws. This system is known as profiled steel sheet dry board (PSSDB) and was introduced by Wright and Evans in 1986 [1] and also Wright *et al*. in 1989 [2]. The central core of the system is PSS and the DB is screwed to PSS in one layer or two layers [2]. In addition, this system may be made by two layers of the PSS and DB, which the recent system is known as double profiled steel sheet double dry board (DPSSDDB) [3]. Fig. 1 shows components of the PSSDB system.

In the last decades, many studies were performed about the effects of explosion load on the dynamic behavior of structures. In this case, dynamic behaviors of various floor systems under explosion load were examined. In recent studies, Iannitti *et al*. performed a study on the dynamic behavior of reinforced concrete slabs under explosion load [5]. Also, Abdel Wahab *et al*. investigated the dynamic behavior of composite V shape panels under explosion load [6]. Based on accomplished studies, no research was found on revealing the dynamic behavior of the PSSDB or DPSSDDB system under explosion load. Therefore, the main aim of this study is to investigate the dynamic behaviors of the PSSDB and DPSSDDB systems under explosion load. For this purpose, effects of various parameters such as the thickness of PSS and DB, kind of DB, screw spacing, floor dimensions, boundary conditions, use of double PSS and double DB, distance, and weight of explosive materials, are evaluated on the dynamic behavior of the studied systems.

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2. METHODOLOGY

Results of the current study were obtained from the numerical finite element method, implemented by ABAQUS software. The option of CONWEP is utilized to apply the explosion load on the surface of DB. In the current study, explosion load is applied to the system in various weights and distances from the center of DB. First, modal analysis was performed on all structural models of the studied systems, to extract their natural frequencies. Second, for all structural models, Rayleigh coefficients were calculated by the first and fourth natural frequencies of the structural models and also the damping ratio of 1.1% which was measured by Gandomkar *et al*. [7] for the studied system. Third, nonlinear dynamic time history analysis was performed on the structural models.

3. RESULTS AND DISCUSSION

Due to the main objective and the sub-objectives of the study, 28 structural models were simulated to show the effects of various parameters on the dynamic behavior of the system under explosion load. These models were verified

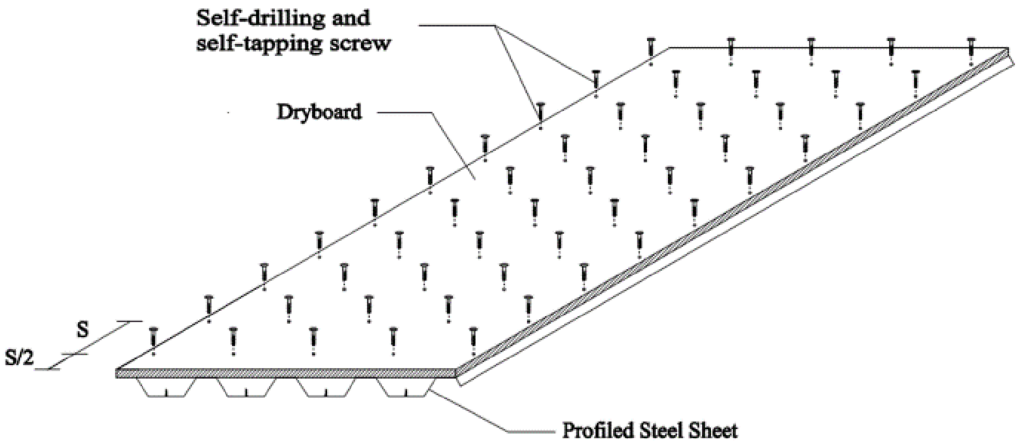

Fig. 1. PSSDB system [4]

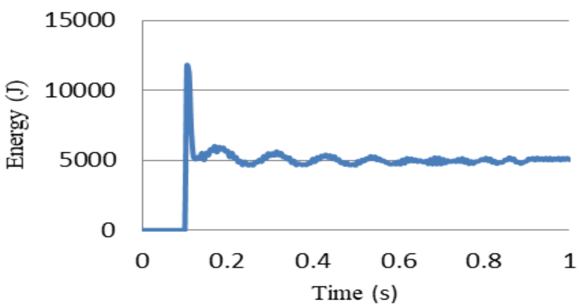

Fig. 2. Time history of strain energy in the base model

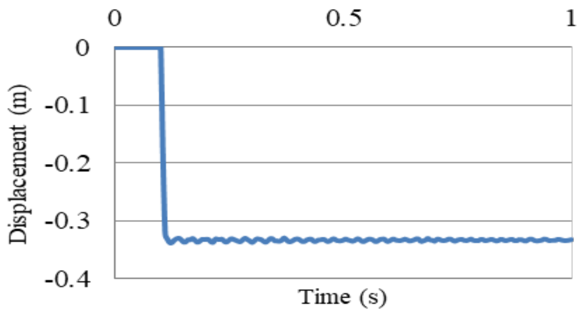

Fig. 3. Time history of displacement at the center of DB in the base model

by the study of Gandomkar *et al*. [5]. A model is considered as a base model with 0.8 mm thickness of the PSS, 18 mm thickness of the DB (Plywood), 200 mm screw spacing, 2385 mm width, 2800 mm length, and both ends simply support, under loading of 10 kg TNT as explosive material with 2 m distance of TNT from the center of DB. For this model, the time history of strain energy, the time history of displacement at the center of DB, and also Von Mises stress contour is shown in Figs. 2 to 4.

The explosion load applies to the system at a time of 0.1 sec. According to Figs. 2 and 3, it is shown a gap in time of 0.1 sec. After that, meaningful changes can be seen in strain energy and displacement time histories, and so free vibration behavior of the studied system is shown after the time of 0.1 sec. By using Fig. 4, maximum Von Mises stresses can be extracted in the PSS and DB. These stresses compare with the yield stresses of PSS and DB materials to show their yielding.

The results uncovered by decreasing thickness of Plywood as DB from 18 mm to 12 mm, maximum displacement increased by 76.35% and maximum strain energy decreased by 29.29%. In addition, by increasing the thickness of PSS from 0.8 mm to 1.0 mm, maximum displacement decreased by 5.63% and maximum strain energy increased by 0.6%. Also, the results showed varying kinds of DB changed the maximum displacement and strain energy of the system, greatly. Furthermore, by reducing screw spacing from 200 mm to 100 mm maximum displacement of the system decreased by 2.69%. Also, by increasing screw spacing from 200 mm to 300 mm, the maximum displacement of the floor system increased by 2.29%. Moreover, when screw spacing increased from 200 mm to 300 mm, the maximum strain energy of the system reduced by only 1.78%. The results revealed by increasing the width of the system from 795 mm to 3975 mm, maximum displacement decreased by 22.14%, and maximum strain energy increased by 364.13%. Also, by increasing the length of the system from 2000 mm to 3200 mm, maximum displacement and strain energy increased by 62.37% and 41.27%, respectively. The results showed varying supports of the system from Pin-Pin in two sides of the system (perpendicular on length of system) to Pin-Roller, maximum displacement and strain energy increased by 165.48% and 13.21%, respectively. On the other hand, by changing supports from Pin-Pin to four-pin supports in four sides of the system, maximum displacement decreased by 30.56%, and maximum strain energy increased by 61.44%. In addition, by converting the PSSDB system to the DPSSDDB system, maximum displacement not changed much, but maximum strain energy was reduced by 45.63%. Also, by

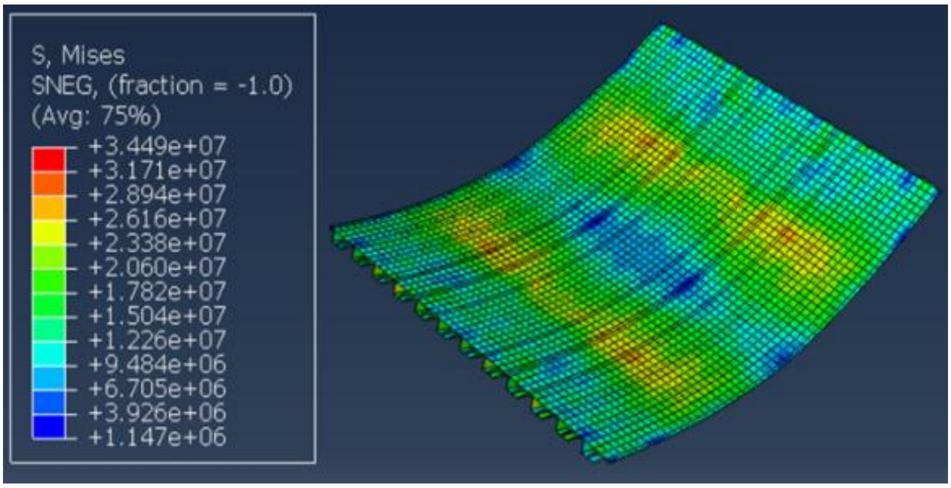

Fig. 4. Von Mises stress contour in the base model

varying supports in both ends of the DPSSDDB system, maximum displacement and strain energy changed by 36.28% and 23.02%, respectively. Furthermore, it was shown by changing the distance of TNT from the center of DB from 2 m to 14 m, when the weight of TNT was constant and equal to 10 kg, maximum displacement decreased by 77.08%, and maximum strain energy-reduced manifold. In the end, the results revealed by the increasing weight of TNT from 10 kg to 30 kg, when the distance of TNT from the center of DB was constant and equal to 2 m, maximum displacement and strain energy increased by 253.86% and 33.34%, respectively.

By comparing the Von Mises stresses of PSS and DB with their yield stresses, it was uncovered unknown effects of studied parameters on conditions of yielding PSS and DB.

4. CONCLUSION

This paper investigates nonlinear dynamic behaviors of the PSSDB and DPSSDDB systems under explosion load by using the numerical finite element method. The results are extracted from ABAQUS software. Effects of changing various parameters such as the thickness of DB and PSS, kind of DB, screw spacing, boundary conditions, floor dimensions, distance and weight of the explosive load, and also using of double PSS and double DB, were investigated on mentioned behaviors. The results of the study showed changing the thickness of DB, kind of DB, floor dimensions, boundary conditions, weight and distance of explosive load, and also using of double PSS and double DB, had considerable effects on varying displacement and strain energy of the system. On the other hand, changing screw spacing and thickness of PSS had not much effect on their changes. Based on the sub-objectives of this study, the PSS and DB reached their yield stresses in some of the conditions but did not reach in some other conditions.

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