Advanced Science and Technology Letters
Vol.120 (GST 2015), pp.189-193
http://dx.doi.org/10.14257/astl.2015.120.36

Improvement of Assembly Tool for Modular Building Technology

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Abstract. Module assembly is an important process in the modular building technology that has a direct impact on structural safety and quality. Manual or electric tools are generally used in assembling modules, but the use of those tools has a number of associated problems, including deterioration in work efficiency and safety. For this reason, this study proposes assembly tools that are designed to improve safety and workability by equipping geared offset and air tools that enable users to work for a long time at a certain quality performance. In addition, the assembly tools proposed in this study were verified through a structural analysis.

Keywords: Modular Building, Assembly Tool, Structural Analysis

1 Introduction

In modular building, a building structure is completed by assembling box-shaped modular units that have been prefabricated at a factory. This technology offers many advantages, including cost reduction and reduction in construction duration, as well as good seismic performance due to its lightness, and as a result it has been widely applied to diverse types of building structures in recent years [1]. Modular building technology can be largely divided into three phases: factory prefabrication, transport, and site installation [2].

More specifically, the module assembly at the site installation phase is an important process that can directly affect the structural safety and quality of the modular building technology. The module units are generally assembled in bolted joint using manual tools like torque wrench or electric tools like corner drill. However, the characteristics of manual and electric tools may be responsible for a number of problems, such as deterioration in work efficiency or worker's safety. For this reason, this study aims to propose an improvement of assembly tools for modular building technology in order to overcome the problems with existing assembly tools and improve the efficiency and safety of modular building technology.

ISSN: 2287-1233 ASTL

2 Theoretical background

2.1 Features of modular building technology

Modular building technology makes it easy to transport a building structure and assemble the modular units using combinations of various floor plans since the modular units can be disassembled and reassembled. Unlike the conventional wet method, a structure is completed in a dry method by assembling module units. Likewise, the modular assembly plays a key role in determining the characteristics of modular building technology. Prewer et al. presents the general features of modular building technology, such as relocatability, adaptability, low weight, design flexibility, and short building period [3].

2.2 Connection method of modular units

Modular units are assembled through a continuous connection at different parts such as between modules, between module and column, and between column and column. These connections of the modular units are required for structural safety, and the assembly method is selected based on the shapes of modules and their appurtenances [4]. There are a couple of assembly methods for modular units, including screw connection, bolt joint, and tablet installation. Among the assembly methods, the bolt joint is most generally used to assemble modular units due to its ease of application.

Table 1. Features of assembly method for modular units [4]

Assembly Method	Features
Screw Assembly	- The shear strength is 5kN in the scenario in which the diameter of a screw is 5.5mm. This is widely used for finishing materials such as plaster board, plywood, floor material, and insulators.
Bolt joint	- The shear strength is 8-12kN in the scenario in which the diameter of a bolt is 12mm. This is often used for steel connection.
Tablet installation	- The shear strength is determined by strength of concrete or bricks on the setup plane. Thin steel materials are hard to connect due to their deformation.

3 An improvement plan for assembly tools

3.1 Improvement of assembly tools

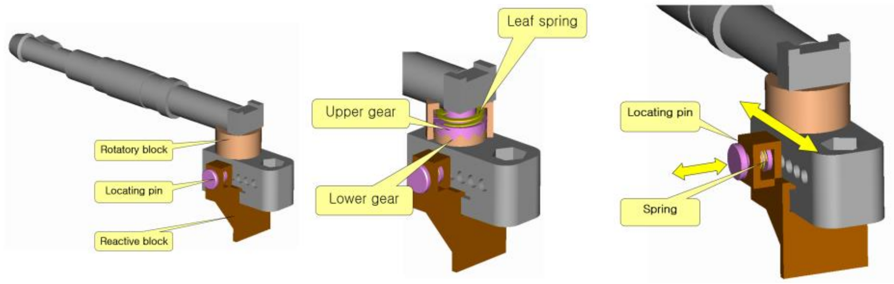
This study focuses on addressing the low work efficiency and safety issues that have been associated with conventional assembly tools. To do this, the conventional assembly tools were compared, considering both manual and electric tools and air tools. Through the comparison, it was found that air tools were most appropriate to work with for a long time at a certain quality performance.

3.2 Design of the assembly tool

Usability and safety are often deteriorated due to the relatively big size and high torque of an air tool. For this reason, an air tool was designed to be equipped with a geared offset to improve usability and safety, as shown in Figure 1(a). The geared offset consists of a rotary block and a reactive block. The purpose of the rotary block is to improve usability, while the purpose of the reactive block is to improve safety.

The rotary block is composed of upper gear, lower gear and leaf spring, and the clamping angle can be changed appropriately for the form of work as illustrated in Figure 1(b). It is possible to change the clamping angle between the air wrench and the geared offset both vertically and horizontally, which brings about significant improvements in worker convenience and safety.

The reactive block that prevents reaction from being delivered to a worker is illustrated in Figure 1(c). There is a locating pin that enables a worker to change the location of the reactive block in order to effectively control reaction according to the steel specification with which a bolt is connected.



(a) An improvement plan for an assembly tool (b) Rotary block (c) Reactive block

Fig. 1. Structure of Improved Assembly Tool

3.3 Verification of structural safety of the assembly tool

The structural safety of the assembly tool designed in this study was verified through a structural analysis simulation. A finite element analysis program, ABAQS, was used to perform the structural analysis, and it was hypothesized that the air tool is integrated with the geared offset. From the analysis result, the maximum stress locally appeared about 215MPa at the connected part between the geared offset and the guide block. However, the stress ranged between 51MPa and 143MPa other than at the highest stressed part. Therefore, it is believed that the improved air tool can be used up to the maximum torque of 325Nm.

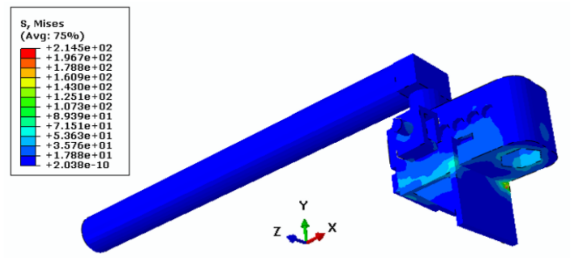


Fig. 2. Result of Structural Analysis

4 Conclusion

In this study, a plan for assembly tools was proposed to improve work efficiency and worker safety. In addition, the plan is also expected to improve the productivity and quality of modular building technology through improvements in torque performance. The improvement plan for assembly tools presented in this study was verified through a structural analysis. However, work efficiency and safety should be analyzed based on monitored data collected through sensors and motion captures from on-site work to understand and address any drawbacks of the improved tool in the future.

Acknowledgement. This research was supported by a grant (code: 15-AUDP-C068788-03) from Residential Environment Research Program(RERP) funded by Ministry of Land, Infrastructure and Transport of Korean government.

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