Modularization and assembly algorithm for efficient MEP construction

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This paper presents an algorithm for efficiently designing, fabricating, and constructing the mechanical, electrical, and plumbing (MEP) systems for buildings. MEP facility construction presents numerous challenges related to its complexity, space limitations, and interference with other trades working in confined areas. Delays are primarily related with the sometimes uncontrollable delivery of fabricated pipe spools and the equipments. This research provides a rational planning algorithm which packages large and complex MEP systems into several smaller fabricated components using spatial planning algorithms to increase the efficiency of the installation process, create a safer work environment, improve construction quality and productivity, reduce construction cycle time, and minimize cost. Furthermore, the technique is verified and validated by three experts and a case study is presented to demonstrate the effectiveness of this algorithm.

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1. Introduction

Mechanical, electrical and plumbing (MEP) systems represent a substantial portion of commercial and industrial projects, where in some cases, they represent 25%–40% of the total project cost [8]. MEP systems directly impact the safety, operating efficiency and energy utilization, and flexibility of the structural and architectural design [7]. Given the importance of the MEP portion of a facility, this research investigates how to efficiently layout and assemble piping systems in the mechanical rooms. Considerations include more efficient distribution of labor, equipment, and materials.

Construction of MEP rooms usually has two major limiting factors, space limitations and schedule delays. These factors typically cause safety issues, space conflicts between subcontractors, delays in piping installation, poor workmanship, and ultimately increased costs.

Space limitations relate to narrow and confined work spaces which make it more difficult to introduce large and heavy pieces of equipment as well as the labor necessary for assembly and installation. Pipes must either be hoisted or installed on the floor of the MEP room and may require complicated pipe supports. Supports installed in these confined rooms create path interference and make installation awkward for pipe fitters. In addition, limited space also causes the cost increasing. When the worker weld the pipe too close to the wall, ceiling, floor or other pipes in the room, they have to use some special method to weld instead of the general method, and the special method is more expensive.

Moreover, when worker weld pipes in a small MEP room in the basement, the ventilation is worse and the toxic gasses generated when they weld would cause them poisoning. Delays are primarily related with the sometimes uncontrollable delivery of fabricated pipe spools and the equipments. This is particularly true in Taiwan and other developing nations where production techniques are maturing and purchases need to be made from manufacturers in other countries. Thus, the delivery time is difficult to control and can influence the construction schedule.

Furthermore, as a customary practice, the pipe in the MEP room is usually installed after many of the other components are in place (walls, electrical conduit, etc.) This is due to concerns that the final facility size...