

Influence Factors of Aerial Environment on Project Schedule Management

Jun-pyo Hong¹ and Hyoung-chul, Lim^{2*}

Abstract: *The objectives of this research are 1) control of schedule or improvement of management for aerial environment, 2) distribution of responsibility to the parties concerned (factory, material company, construction company, design and engineering, occupancy). The results show the relative priority of the four major items in wall-based apartment buildings and in column-based apartment buildings. An analysis of the parties responsible for improvement based on the IAQ results shows more efforts to improve IAQ are needed in material factories and engineering/design companies.*

Keywords: *: Aerial Environment, influencing factor, Phase of Building Construction, apartment building*

I. INTRODUCTION

A. Research background and objective

As the interest in the toxic substances generated in residential spaces has been on the rise, many efforts have been made to reduce the presence of such toxic substances in newly built apartment buildings by raising awareness, reinforcing regulations and distributing responsibility appropriately among participants in the construction industry. In particular, it should be noted that unlike other building structures, apartment buildings have a small area exposed to external air, which is recognized as disadvantageous in terms of ventilation. Increased demands from residents and advances in construction-related technology have led to a deteriorated IAQ even before occupancy due to a shortened construction period as well as an increase in toxic substances emitted and different types of interior finishing materials

This research, therefore, aims not only to derive the influencing factors that can lead to improvements in operation and management at the site and changes in the schedule of the interior finishing work, but also to determine the relative priority of managerial and applicable procedures in order to improve the IAQ not the conventional research areas, including the elimination of pollutants from the construction materials used in the apartment building and their control after completion, and the development and use of eco-friendly materials.

Through the appropriate management and application of these influencing factors, this research aims to present a fundamentally improved method at the managerial level

that can control the schedule of construction, improve schedule management and enhance the responsibility for pollution prevention by appropriately distributing the responsibility among the parties concerned (material manufacturers, factories, logistics companies, subcontractors, and person(s) in charge of material storage at the site).

B. Research scope and method

As preliminary research, a review of previous literature, actual conditions, and practical data was carried out to analyze the influence of each material used in an apartment building. The category of the air quality control for the finishing work was prepared, and a process model was drawn to determine the relationship between the interior finishing work and deterioration of the air quality.

To improve the air quality shown in the process model by securing manageability and improving effects, two surveys were conducted: one to derive the managerial priority and the other to adjust the process managing body. Based on the surveys, a management improvement plan was prepared to distribute the responsibility for reducing the pollutants among the parties concerned, including material manufacturers, factories, logistics companies, subcontractors, and person(s) in charge of storage at the site.

The research scope is limited to the finishing work of an apartment building, and it is performed based on the category derived from the linking analysis of the standard specification and the master format.

The following describes the methods in detail.

First of all, for the theoretical review on the air quality of apartment buildings, pollutants were analyzed by performing an analysis of previous research, not only on the development of eco-friendly materials and chemical

¹ Master's course, Dept of Architectural Engineering, Changwon National University 9 Sarimdong Changwon Kyong-Nam,

² Associate Professor, Dept of Architectural Engineering, Changwon National University 9 Sarimdong Changwon Kyong-Nam, hclim@changwon.ac.kr (*Corresponding Author)

treatments, but also on bake-out and cases of practical applications.

Then, the Finish System Breakdown Structure (FsMS) was drawn by conducting a linking analysis of the standard time schedule, the standard specification and the master format in order to classify the interior finishing work by process and consider the factors for process change. A standard process model is developed for the IAQ based on the category, and surveys are conducted to analyze factors influencing the IAQ and derive the relative management priority.

To perform an analysis of factors for process change and the effects resulting from management control by the participants, the participants for management are selected based on the critical path management technique; managerial priority is derived according to float time and relative amount of pollutants released at a given work section; a survey of the participants on the effect of the IAQ is conducted; and a prior control model for each participant is developed.

II. THEORETICAL RESEARCH

A. Review of the related research

Related research can be largely divided into material-related research and IAQ management technique-related research.

The material-related research on pollution reduction is mainly limited to the premise that it is necessary to improve materials based on an actual survey and analysis of materials that can induce pollution. The IAQ management technique-related research is mainly limited to a description of the effects of materials that emit less pollution.

As discussed in the research recently done by Lee, YG and Kim, JW, changes in the working schedule and construction technologies have been partly incorporated in the IAQ management technique, including pollution control. Despite such attempts, most of the research is limited to the amount of pollutants that are emitted, either after the pollution reduction treatment or after the 'bake-out' immediately before occupancy.

Such measures and improvement plans are usually performed after the finishing material work, or even immediately after extensive ventilation or bake-out, so it seems difficult to consider them as a fundamental solution to the issue of pollutants

B. Review of cases of practical

The cases of practical application reviewed include a study on the ventilation system done by Seong, KC (DW Construction), a study on the bake-out done by Kim, MW (SS Construction), a study on influencing factors on the IAQ done by Hong, GP (DS Construction), and an experimental study on pollutants (SA Construction), all of which have been conducted by construction companies to

improve the IAQ and are actually applied to new apartment buildings.

Despite the fact that improving the IAQ should be considered from the material design stage to the construction cost estimation stage, apartments are mainly sold by constructors based on their unique characteristics. Constructors should consider improving the IAQ as a design change that can differentiate their apartments from a marketing perspective.

For this reason, improvement of the IAQ has long been a social interest, and has also been requested by residents of apartment buildings, and construction companies have steadily applied eco-friendly materials and materials that release less pollutants. However, efforts to improve and review the applicability of such materials should be made due to realistic problems related with construction schedule, a lack of awareness among participants, and concerns about increased construction costs.

Therefore, as described in the previous cases, most construction companies in Korea take an approach to IAQ management in addition to an approach to materials. According to the studies done by Seong, KC and Hong, GP, while bake-out and ventilation seem to greatly improve the IQA in the short run, the results are not equal in effect, and the IAQ deteriorates over time.

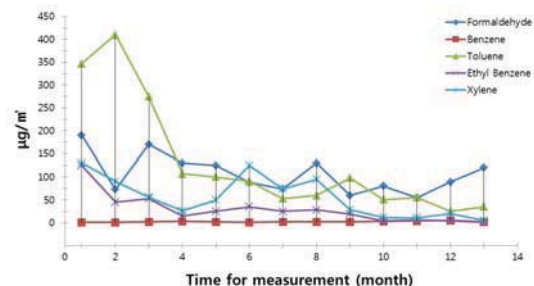


Figure 1. Density of IAQ pollution substance

B. Research differentiation/requirements for improvement

Based on a review of the existing research on IAQ techniques, including pollution reduction processing, factors for process change and a management system were derived.

From the review, it was also found that ethyl benzene and styrene are around the acceptable exposure levels. However, formaldehyde and toluene are prone to deteriorate the IAQ more than other pollutants, so the need for prioritization to manage and control them in the course of construction work should be understood.

In order to establish the validity and research direction based on the review results, the need for and feasibility of changes in the schedule at the site to improve the IAQ after occupancy were studied as follows.

The research subjects consisted of 5 schedule managers in charge of the site process of apartment buildings with more than 300 households that are now under construction (denoted as S in Fig. 2), and 5

construction managers (denoted as C in Fig. 2), and Fig. 2 shows the research results.

Both schedule and construction managers positively responded to the need for the IAQ in many different fields, while the construction managers gave a strongly negative response to questions about its feasibility.

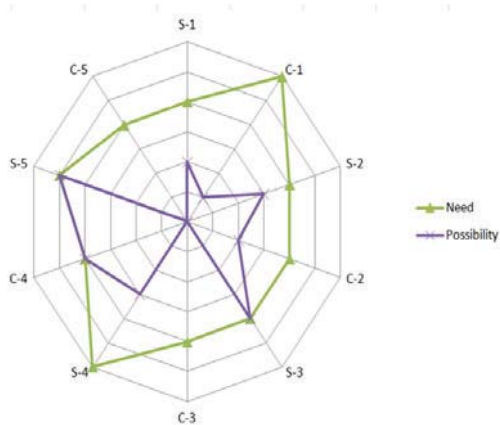


Figure 2. Results of survey

Therefore, the research results revealed that it is needed to take an procedural approach through prioritization and minimize the changes taking into account the conditions of the site where the finishing work is done

III. THEORETICAL RESEARCH

A. Relative priority based on an analysis of the aerial environment by schedule

As is already known, since internal factors such as materials, construction and design factors including selection of materials, ventilation volume, and pollutants are intertwined with the external factors, which affect the processes of Level 2, it is hard to assume that such factors affect all processes at a consistent level.

Therefore, a paired comparison interview was conducted among professionals and persons in charge using a 5-point scale. The interview covered the categories of the FsBS, which is the relative schedule management that should be generally considered for air quality control; as well as the question of which party should be responsible for the improvement of the IAQ, by dividing the participants into designer, material producing company, construction company, and resident.

To determine the priority between the items of the questionnaire, an AHP-based survey was conducted. However, this method was applied only to the processes in Level-1, which are newly composed by putting more weight on relative priority than quantitative preference value of each work type, rather than the sub-tiers including those in Level-2, because the conditions can vary depending on the selection of materials and the site itself.

In addition, Table 4 shows a summary of the survey conducted in this research, including the relative priority,

the establishment of a classification system, and an analysis of the cases of practical application.

The survey results are shown in , Fig. 3 and Fig 4. It is found that for wall-based apartment buildings, a relative priority was put on finishing work, floor work, masonry work, and furniture work, in that order, while for column-based apartment buildings a relative priority was put on finishing work, furniture work, floor work, and masonry work, in that order. Although the relative priority of the work processes appeared to be similar in both types of buildings, there are some differences in the reinforced concrete protective covers, ceiling panel work for the Rahmen structure, and curtain wall caulking of the curtain wall. However, there are wide variations in priority among items.

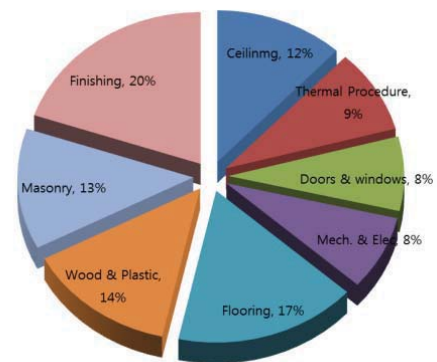


Figure 3. Relative priority in wall-based apartment building

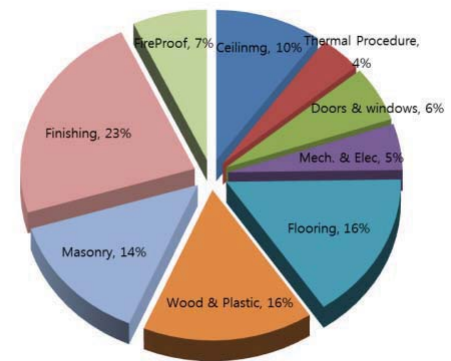


Figure 4. Relative priority in column-based apartment building

B. Analysis of the process control effect by relative priority

Finishing work can be divided into two different paths: the critical path including masonry, papering, and flooring, and the general path including doors and windows work, tiling and furniture work. Masonry work is the framework, the schedule of which cannot be changed. The

schedule control effect was analyzed by limiting the milestone activities to two types of work in the critical path and three types of work in the general path.

The analytical results of schedule management with no change in paths are as follows. The float time of the critical path is '0,' and the schedule is impossible to change. As a result, the doors and windows work, tiling and furniture work in the general path are analyzed, and then the float time and intensity of pollutants of individual work are enumerated.

However, it is assumed that 6.3 kitchen furniture work with the mark '*' is completed in a two-step installation, and that individual processes do not have any relation with other households and buildings. If it is possible to work on each part, the factors to restrictively interfere with work are not taken into account. For instance, the sequence of work sections is not considered, including papering after the installation of a windowsill, baseboard work after papering, and wall tiling after floor tiling.

As you can see in Table 6, the relative intensity of any release of pollutants is shown to be high, in the order of papering, furniture work, doors and windows work and tiling. Of these, some papering and plastering is included in the critical path, and the schedule of the works can be changed. The float time of the front door work and the aluminum doors and windows work is long, but pollutants are not emitted during such work. Taking the float time and the relative intensity of releasing pollutants into account, one can change the schedule of furniture (90 days), wood doors and windows (75 days), and tiling (150 days) to control the period of time of releasing the substances.

Also, in terms of work sections such as kitchen furniture and storage furniture work, which have a long float time and release large amounts of pollutants, the work should not solely depend on the float time in consideration of the fact that the work sections done immediately before and after the furniture work are done en bloc, by floor or by building. The efforts to improve the IAQ should be distributed among material factories, logistics companies, and even the person(s) in charge of the storage at the site.

In the schedule management, the float time should be considered not as a time slot in the schedule during which nothing needs to be done, but as a kind of buffer during which the variations of sequential works can be dealt with depending on the field conditions. From this perspective, it is necessary to manage the schedule in a way that is flexible and can suit each household rather than to manage it en bloc. Furthermore, it is desirable to selectively apply the flexible schedule to the work sections that can greatly improve the IAQ by doing so.

According to 'Figure 1. Density of IAQ pollution substances,' toluene is found to be released most in the initial two months but declines to approximately 20 percent of the maximum level after four months, while formaldehyde is released from various items, and the amount released does not show any clear relationship with the time elapsed.

Therefore, based on the idea that a large amount of toluene is released from one to four months after

work is done, the work that has a long float time should be done as early as possible in order to allow the pollutants to be released for a relatively long time prior to habitation.

IV. CONCLUSION AND FUTURE RESEARCH DIRECTION

It is found that for wall-based apartment buildings, a relative priority was put on finishing work, floor work, masonry work, and furniture work, in that order, while for column-based apartment buildings a relative priority was put on finishing work, furniture work, floor work, and masonry work, in that order. Although the relative priority of the work processes appeared to be similar in both types of buildings, there are some differences in the reinforced concrete protective covers, ceiling panel work for the Rahmen structure, and curtain wall caulking of the curtain wall. However, there are wide variations in priority among items.

From the analytical results, constructors and residents were responded as the party responsible for improving the IAQ among the 4 participants, Overall, other parties except for constructors pay little attention to improving the IAQ. Therefore, cooperative efforts should be made by factories and designers in order to reduce the pollutants

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