

Research on the Emergence Mechanism of Last Planner System of Lean Construction

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Abstract: The Last Planner System is a very important and systematic method that influences the achievement of lean construction. With the theory of emergence science, this paper analyzed the emergence mechanism of the last planner system from the perspective of group decision-making, information change and self-organization; then, how to realize the potencies of the last planner system so as to attain much emergence was discussed.

Key Words: Lean Construction; Last Planner System; Emergent Property; Complex System; Group Decision-Making

1 INTRODUCTION

The Last Planner System (LPS) is a method system mainly recommended by two lean construction research and extension organizations, namely International Group for Lean Construction (IGLC) and Lean Construction Institute (LCI). As a practical method, LPS changed the too general and rough disadvantages existed in planning and control process of traditional construction methods, improved the efficiency of planning and control, effectively improved the construction project management performance. A live demonstration result of LCI showed: LPS can improve many aspects of performance in construction projects, which include construction quality, construction period, profits, building materials inventory and construction personnel management [1]. Via 5 years of residential construction practice in Denmark, Sven Bertelsen found the benefits implementing LPS is as follows: pay more attention to customer value, shorten the project completion time, fewer defects and omissions and high customer satisfaction [2]. Luis F. Alarcon et al. collected the Chile's data that implement lean construction, and focused on the investigation of 12 Chilean construction company, they found the benefits that implement LPS are: management and control ability has been improved, more middle management layers are involved in management, emergency requirements are reduced, the productivity increases, the waiting time is reduced, better cooperation and construction period is shortened [3]. Via direct observation, interview and questionnaire survey, O. Salem et al. analyzed the effectiveness of lean construction tools, it was found that LPS was evaluated higher than the expected [4]. According to the criteria proposed by Muller [5] that determined whether a system has emerged and lean construction experts' discussion, such as Sven Bertelsen and Lauri Koskela [6], we can conclude that the implementation of LPS can make the new "quality" that traditional management methods can not meet in construction projects emergence. Therefore, research and discussion on the emergence mechanism of LPS in order to explore the role of LPS emergence have great theoretical value and practical significance.

2 INTRODUCTION TO LPS [7,8,9]

2.1 The Concept of the Last Planner System

The Last Planners are those of primary managers that directly assign tasks to workers, such as a shift foreman or design team leader. The Last Planner System is the management system focusing on short-term and primary production planning improvement in construction production. Due to the primary managers could participate in the project planning and decision making, LPS can make all construction management personnel understand the current state of the construction project, and let the project plan more accurate. At the same time, according to the implementation status of the project, LPS can continuously control project progress. Compared with the traditional scheme, the special of LPS is the last planners who plan workflow is involved in planning, this makes the output become the specific work rather than other forms of plan, which makes the work process in a controllable scope.

2.2 The Preparation of LPS

The traditional plan views the work should be done as the work able to be done, without considering whether the implementation of work has constraint conditions or not, which lead to actual project deviates from the plan. LPS divides plans tasks grouped into the following four types: the work that needs to be done according to the progress (Should); the actual work that can be done because of the project constraints (Can); the work promised to finish after evaluating all constraints (Will); the work already done (Did). Taking into account the project implementation constraints, this may cause by the work executor because of their own resources and capabilities, LPS let the plan directly to construction production, which also makes the plan more reliable. LPS can be divided into the following three levels:

The master plan. In LPS, the master plan should be done according to the project target and information, and the work needed to complete for the project must be pointed out (Should). Some problems for a long period of time,

such as the progress of the project is reasonable or not, staffing is adequacy or not, supplier selection is reliable or not etc., can be analyzed through the master plan.

Lookahead plan. Lookahead plan is a rolling plan, its formulation should consider not only the master plan, but also need to combine the current work status on weekly work plan execution. The matching of production preparation and production capacity can complete through lookahead plan, the work able to complete can be identified through lookahead plan (Can).

Weekly work plan. The already completed (Did) and unfinished work are considered by the weekly work plan. By doing so, it can make a commitment to the upcoming work (Will). The weekly work plan is the short-term and underlying plan, so the accurate and reliable requirement is needed, and requires the analysis of the PPC (Percent Cost Complete) that shows work implementation status and unfinished work to grasp the real-time work condition. In the weekly work plan, planners and implementers are unified.

2.3 Control of LPS to Project Implementation Process

The main purpose of implementing LPS is realizing the workflow control in the construction process. It includes two aspects: control of the production unit and control of workflow. Production unit control is to determine the scope of work of the weekly work plan through continuously improving assigned workers' task, it is the basis for the LPS' implementation. Process control is to make the different production units smoothly connected in accordance with the expected order and rate. In LPS, the lookahead plan is used to protect the stability of different production unit's workflow.

LPS improves the connection of all aspects of the work, great changes have been taken place in the whole project delivery work, all this has effectively accelerated the implementation of lean construction and project performance's emergence. In fact, the emergence of LPS is not appeared out of nowhere, it has the objective root that can be found and searched and the mechanism that can be revealed using science theory.

3 THE EXPLANATION OF LPS EMERGENCE MECHANISM FROM THE PERSPECTIVE OF GROUP DECISION MAKING

The decision problem is a very important problem in the project implementation. With the gradual implementation of the project, more and more problems need to be decided, the problem also becomes more complex. Any single personnel with their experience and wisdom is difficult to cope with all the decision problems. Therefore, planning and decision making usually need different levels of managers in the process of implementing project.

In order to ensure the smooth implementation of construction projects, we must completely change the instruction method that carries out from top to bottom, and let the plan directly face the implementation, face the workers or working team that have the actual operation task. The implementer of each production activities may make

plan and execute according to its own situation, LPS is put forward exactly based on the traditional plan's aforementioned drawbacks.

In LPS, the master plan focuses on grasping the project goal from the whole from the angle of the planning process, and considers all the relevant organizations and individuals by project-centered to coordinate their cooperation between them. The master plan's participants include not only the top manager, but also low-level managers. This is helpful to put forward various work arrangements around the problem needed to be solved in construction project. Lookahead plan can revise the implementation of the master plan and put forward specific implementation measures to fulfill project goal. Lookahead plan is formulated by all low-level managers, and low-level managers agree to carry out the plan. Because the low-level managers is familiar with the construction production process, the lookahead plan above-mentioned can solve the practical problem pertinently; and more specific the problem is, more the measures have a definite object in view, more obvious effect the plan will obtain. Weekly work plan is made by the construction personnel according to the construction site conditions, and is done correctly as far as possible. So, LPS will be gradually specific after the master plan, lookahead plan and weekly work plan. The contact between macro and micro level that construction projects emergence requires is established. LPS reflected the fine management of lean construction, that is to say, LPS can consider the problem from macro and pay attention to deal with the important small points from the micro, so LPS can make more sensitive decision to external resource requirements and information changes.

From the principal of participating in decision making, LPS improves plan reliability using a pull-type process design and achieves goals by decentralized control. LPS ensures the work participation rights of the low-level managers, and reflects the proper decentralization leadership in plan making and production control. In the planning and implementing, top management is concerned with the overall goals and project constraints, and deploys the implementation of project on the whole, and creates conditions for the timely communication between department and between each of the construction process. The low-level last planners of project mostly come from different organizations and have independent planning ability. Because directly facing construction production, they understand their ability and resource constraints, can recognize what kind of work is his responsibilities and the specific work they need to complete in a certain period, and constantly adjust the corresponding countermeasures, which reduces oscillation and loss that a variety of variable factors bring. At different stage of project implementation, the plan is formulated by different levels and functions managers through mutual cooperation, this is helpful to fully draw out their collective wisdom and improve execution of the plan, and let the ability and performance from group decision making is far beyond the ability and performance from the same number of individual decision-making, which makes decision making ability that the construction project shows in the LPS implementation process is different from the each individual has, the above

activities that the whole has but the local didn't have lead to the emergence of the construction project performance.

4 THE EXPLANATION OF LPS EMERGENCE MECHANISM FROM THE PERSPECTIVE OF INFORMATION CHANGE

In the process of construction project management, large amounts of information need to deal with, such as the information from different participants, different process and functional management sector, and different forms of information etc. Information makes the emergence possible mainly lies in three aspects: the characteristics of simultaneous use, the characteristics of no wear when repeatedly using and synthesis. Decision is correct or not is closely related to the timely and accurate information which come from all kinds of source. LPS includes a large number of functions related to information processing, which can improve the efficiency of information communication, and improve the quality of information communication, and also make the planner have a good grasp to the implementation status of project.

In LPS, lookahead plan plays a very important role. Managers may predict the completed work, work order and work package sizes in lookahead plan to provide basis for the establishment of weekly work plan. This includes: the order and rate design for workflow; matching workflow with the corresponding ability; dividing the master plan into work packages; perfecting specific work execution method; ordering for the upcoming work; updating or revising the above layer plan if necessary. Process for the preparation of lookahead plan is the process that the fuzzy project information gradually becomes transparent, and also the process which the information asymmetry between project members is continuously eliminated. Scroll preparation of lookahead plan ensures the variety of information delivery and transmits them in a timely and smooth way in internal and external organization. So, the information of different stages is shared, the efficiency of interactive communication is improved, the problems caused by information conflict, not standardized and feedback slow etc. are eliminated, the implementation situation of the project is timely and accurately reflected. In LPS, lookahead plan actually plays the "emerging media" role. From lookahead plan, top management may understand project progress and constraint conditions of implementation, and the last planners can also understand the project's dynamic situation and timely arrange the weekly work plan combined with their own actual work condition.

Weekly work plan is grasped by the workers or working team or group executing the actual operations, which is conducive to timely feedback project information and discover the potential problems. PPC is the determination index reflecting the efficiency of plan execution, in addition to the performance measure function, another important function of PPC is carrying on the analysis to the unfinished work, and timely detecting problems and improve. Analysis and improvement for these problems is not limited to the production unit, the whole production process is also

inclusive. If necessary, the lookahead plan even master plan can be adjusted according to the analysis results to prevent the occurrence of errors. So, by means of the measurement and the cause analysis of PPC, LPS' information can improve itself through dynamic self monitoring, which provides a strong support for the construction projects to achieve reliable workflow.

The information may reflect the complexity of system, namely non symmetrical degree or structuring degree. In the implementation process of LPS, project performance is improved with negative entropy which resulted from participants' information interaction. The appearance and disappearance of emergence phenomenon could not make physics and energy existed in the real world increase or decrease, so in the final analysis it is the information changes and information increase or decrease make it so. LPS may change the contact way and the close degree between the project participants, namely, may change the type and quantity of information. All these realize the information proliferation of whole project management system, and ultimately realize the prompt of the overall management system order degree and the appearance of emergence.

5 THE EXPLANATION OF LPS EMERGENCE MECHANISM FROM THE PERSPECTIVE OF SELF ORGANIZATION

Construction projects is constituted by tens of thousands of activities which is mutual influence and restriction in time and space, various participants need to be coordinated together organically in the construction process. Due to the respective interests belonged to the various parties is different, which has brought about the construction project fragmented nature and antagonism. Fragmented nature and the antagonism lead different actors in construction projects system to interact continually, as a result, they all actively try to transform what is happening to their advantage factor when facing some changes, such as the external environment, technology changes, engineering changes and the price adjustment etc. Fragmented nature and the antagonism affect the nonlinear relationship between participants interface in construction projects and make the construction process more spontaneous, no order, and more active.

LPS' formulation is carried out in a series of exchanges. All participants involved in the project can timely understanding about the information which is related to the quality, schedule and cost control etc. Mutual trust and cooperation of the participants involved in the construction project will be enhanced through exchange. During the plan making, LPS let the last planner directly involved in the preparation process and accepts their opinions on how to construction. So, the last planner doesn't just passively accept the instruction, they can make decisions according to the actual working condition, resources available and their ability, which not only give them the opportunity for innovation and thinking, but also improve their initiative and creativity about implementation. LPS does not be completed by an individual or a team after one plan

compilation, it will continue throughout the life cycle of the project, while this requires joint effort of entire project organization. LPS enable the participants in conjunction with each other by means of planning, the dynamic self organization would achieve after mutual excitation and mutual complementation.

In the implementation of the plan, the complexity, dynamic and nonlinear of the construction process make the implementation process appear greater uncertainty. LPS can constantly control project progress according to the implementation status, the process of should-can-will-did of LPS is the process of decentralized control, also the process that using local mechanism of last planner impact the global behavior. Through this process, deviation can be timely processed and the reason can be found out in the work. Therefore, the whole construction process can be considered as a studying process at this time, it can be self organization and self studying, in which all of the staff and organization will continuously learn as a whole, at this time, the construction project will achieve bidirectional association in the microscopic and macroscopic level through the study.

In construction project, the adaptive learning process of participants in LPS is also the process of nonlinear interaction between them, which is equivalent to a positive feedback. On the one hand, the subject can be self organization, self coordination, self strengthening and expanding development subsequently; at the same time, each participants will strengthen the learning function associated with positive feedback to enhance their ability of existence, These interactions can make the project produce a spontaneous self-organization as a whole, which will led to the project organizations transfer no synergy into high degree synergism, the overall structure of the project will change from disorderly to orderly. According to the viewpoint of synergetics theory, synergetic and ordered are a pair of dialectical causality. Namely, synergetic is the reason of ordered, order is the result of synergetic. Results feedback to reason, the synergistic effect is more obvious. Finally, a qualitative change in construction projects will happen in this self-adjustment process, the overall performance and features will emerge very naturally.

6 DISCUSSION AND CONCLUSION

Not all the projects which implement LPS will produce emergence, the efficacy of LPS is controversial in two lean construction organizations. Investigating its reason, LPS is a refinement management methods, LPS' whole emergence cannot do without the close cooperation between the main participants. However, the participant in construction projects is adaptive agent with cognitive ability, one-off game makes the participants in project management bear their respective mandates mainly by contract, commission or other relevant forms. The game between the project participants is actually a win-lose relation. Therefore, how to develop appropriate contract and make the participants remain credible commitment is the key of project management. Meanwhile, project managers need to invest more time and effort to improve the participants'

consistency and continuity based on mutual understanding and cooperation idea.

LPS whole emergence has great relations to its external environment. The interference of the external environment will affect nonlinear relationship between the various elements in construction projects. If a link or factors has improper disposal, nonlinear interaction will produce relation to enlarge by fluctuations and release the butterfly effect, the continuity of the workflow will be difficult to maintain. Of course, the influence of the external environment is not always negative effect. Self organization theory shows when system evolves to a certain bifurcation point, system will face with multiple possible prospects which is symmetric to each other, while the system itself cannot break this symmetry. The realization of symmetry breaking choose must rely on environment-induced or accidental factors, and good physical environment, institutional and social environment is conducive to establish a platform for the implementation of lean construction, which undoubtedly can also provide support for the emergence of LPS. This also could explain the reasons why LPS in abroad can get extensive research and practice, but it is difficult to implement in China.

Emergence theory provides a new perspective for us to understand and interpret LPS. Due to the emergence of construction project is a complicated process, the emergence of procurement on time, construction on time, kanban management, modular construction, lean quality assurance and 3D technology etc. in Lean construction also require researchers to work together to reveal. As a new model for complex, uncertain and fast construction projects, China's academic and practice staff should strengthen study on lean construction in order to promote its implementation and the emergence of construction performance in China.

REFERENCES

- [1] Guangyu Qiu and Ronggui Liu, Study on lean construction feasibility in China's construction industry, *Sichuan Building Science*, Vol.34, No.2, 253-256, 2008.
- [2] Sven Bertelsen, Lean construction as an integrated production, *Proceedings IGLC-9*, Singapore, 2001.
- [3] Luis F. Alarcón, Sven Diethelm, Oscar Rojo and Rodrigo Calderon. Assessing the impacts of implementing lean construction, *Proceedings IGLC-13*, Sydney, Australia, 387-393, 2005.
- [4] O. Salem, J. Solomon, A. Genaidy and M. Luegring. Site implementation and assessment of lean construction techniques, *Lean Construction Journal*, Vol.12, No.2, 1-21, 2005.
- [5] S. Y. Auyang, *Foundations of Complex-system Theories: In Economics, Evolutionary Biology, and Statistical Physics*, Shanghai: Shanghai Science and Technology Education Press, 2002
- [6] Sven Bertelsen and Lauri Koskela. Construction beyond lean: a new understanding of construction management, *Proceedings IGLC-12*, Elsinore, Denmark, 2004.
- [7] Ming Li and Tongyin Han, Application of last planner system in construction production management, *Construction Economy*, No. 12, 104-107, 2008.
- [8] Chaozhi Li, Lijuan You and Jiankun Zhang, Last planner technology, *Journal of Southeast University(Philosophy and Social Science)*, Vol.11, No.6, 131-134, 2009.
- [9] Dao-zhi Zhao and Geng Chen, Research on the planning and controlling system of construction project based on the "Lean Construction", *Journal of Hebei Institute of Architectural Science and Technology (Social Science Edition)*, Vol.23, No.3, 1-4, 2006.