

METHOD OF PACKING AND INSTALLING OF PREFABRICATED COLLAPSIBLE CAGES.

FIELD OF THE INVENTION

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The present invention relates to the assembly and installation of reinforcement structures for concrete members in the construction industry.

BACKGROUND OF THE INVENTION

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In the construction industry today, the assembly and installation of reinforcement steel cages for the reinforcement of concrete structures is largely an affair of manual labor. A team of workers are responsible for the assembly of these cages using loose steel parts. These parts are generally in the form of preformed bars, links and wires meshes. Once assembled, these steel cages are lowered or installed into formworks. Formworks are commonly used in the construction industry as moulds for the curing or setting of concrete.

A supervisor leading the team is responsible for reading and interpreting complex floor plans and steel reinforcement detailing drawings. He has to identify the composition and the configuration of each steel reinforcement cage required in the construction site he has been assigned to. (Composition means the required number, sizes and shape of steel parts required to assemble the cages. Configuration means the location of each steel part within the cage structure.)

The supervisor then conveys his instructions to his team verbally, instructing them to assemble the required number of cages as well as their composition and configuration. In addition, he also marks down instructions in the vicinity of the formworks where the steel cages are to be installed. The team of workers then assemble the cages in the construction site near the formworks. Once completed the cages are lowered or installed into the

formworks. Alternatively, the workers can also transport the loose steel parts into the formworks and assemble the cages there.

The current conventional method of steel cage assembly and installation is highly dependent on the supervisor's personal ability and communication skills.

The assembly process of the cages are themselves time consuming. The steel parts required for cage assembly are pre-packed according to their respective dimensions and shapes. The workers need to sort the steel parts, collect the required ones and assemble them into the required configuration of cages. This largely manual process also relies heavily on the skill and diligence of the workers. The lengthy assembly time delays and increases time taken to install the steel cages into the formworks.

The invention of prefabricated Collapsible Cage (hereinafter referred to as precage) by the same applicant in Singapore Patent Applications no. 9905163-3 of which one of the aims is to address the issues of assembly of steel reinforcement cages. The invention allows cages to be prefabricated in a factory environment where systematic production processes and suitable quality control methods are implemented. However, with the utilization of precages at construction sites, a new set of concerns arose which were not dealt with previously.

As part of reinforced concrete design, steel reinforcement cages of adjacent structural elements often need to interlace or cross with each other to achieve anchorage and stress transfer. These interlacing or crossings pose unique problems when precages are used in the formworks to reinforce the concrete structures.

In current industry practices, when conventional steel reinforcement cages need to be crossed, there are two general approaches taken;

1. The cages are assembled right above the formworks in their crossed configurations. Once completed , the entire assembly is lowered together, still crossed into the formworks.
2. The cages are assembled in the formworks and are crossed as the cages are being assembled.

These two methods do not apply to precages as precages are fully assembled when they reach the construction site. The precages are heavy, unwieldy and difficult to move around even in their collapsed form. Fig. 1 shows a typical crossing of two adjacent steel reinforcing cages. Fig 2 shows a typical floor plan of an apartment requiring installation of steel reinforcement cages labeled T1 to T15.

Precages being heavy are not easily adjusted during their installation. If the crossings are not done properly or in the right sequence, there would be a lot of difficulty encountered in trying to adjust the precages.

Furthermore, construction site environments are generally uneven with obstacles that hinder movement and maneuverability. Therefore, it is critical that movement of precages be further minimized during installation. These concerns further aggravate the already difficult task of interlacing or crossing of these fully assembled precages.

Lastly, planning and execution of the present precage installation is still at the discretion of a supervisor. He still has to communicate instructions to the workers directing them to install the precages in a manner that he sees fit. This reliance on personal ability of the supervisors results in varying quality of work that varies with different supervisors. This inconsistency of work makes for poor planning and scheduling especially if the time to completion of precage installation is unsure.

As will be described, the present invention provides a method of packing and installing that will alleviate and reduce the problems that accompany the utilization of the prefabricated collapsible steel cage.

SUMMARY OF THE INVENTION

An objective of the invention is to develop a method for planning the packing and installing precages at a construction site such that there is minimal handling and movement of the precages during installation.

Another objective of the invention is to minimize adjustments to the precages during installation.

5 Another objective of the invention is also to become independent of the skill level of the workers performing installation of the precages.

BRIEF DESCRIPTION OF THE DRAWINGS

10 Fig. 1 shows a typical crossing of two steel reinforcing cages; a main cage
and a subordinate cage.

Fig. 2 shows a floor plan for an apartment requiring the installation of steel reinforcing cages.

Fig. 3 is a block diagram showing the sequence of individual processes that
15 make up a method of planning of precage installation.

Fig. 4 is a block diagram showing the information required for the planning of precage installation.

Fig. 5 is a block diagram showing the steps leading to an assignment of installation sequences.

20 Fig. 6 is a flow chart illustrating a method of assigning main cages to a
sequence.

Fig. 7 is a flow chart illustrating a method of assigning subordinate cages to a sequence.

25 **DETAIL DESCRIPTION OF THE DRAWINGS**

The method of the packing and installing of precages for a construction site begins with a detailed analysis of relevant design drawings and ends with the detailed plan showing the installation sequences and bundles of pre-packed precages. Primarily, what is intended is a complete system that enables the management of the entire process of precage installation right from the assembly, packing to installation.

Referring to Fig 3, the general steps in method 300 for the packing and installation of precages are laid out. The method begins by analyzing 310 and extracting the relevant information with regard to the construction floor plans and the details of the reinforcing steel cages. A typical construction floor plan is shown in Fig. 2. Finally, the assigning of installation sequences 315 of the precages resulting in separate bundles of packed precages.

Referring to Fig 4, step 310 shows the analyzing and extracting of required information. The relevant information are :

- a) the location of the formworks from the floor plan 410;
- 10 b) the dimensions and weight of the reinforcing steel cages 415;
- c) the crossing conditions 420 of the steel cages;
- d) the heaviest and often the main cages also have to be identified 425.

Main cages are predominantly larger and heavier than other cages. 15 They act as main supports, and play a major role in load distribution in the overall floor plan. Being heavier and bulkier, the main cages are often installed first to minimize adjustments especially when there is a need to cross them with lighter non main cages. Hereinafter, all cages that are not main cages are referred to as subordinate cages

20 When considering crossing of cages, a general rule is that all subordinate cages will be crossed onto main cages. This ensures that constituent parts of the main cage i.e. the preformed main bars, are resting at the bottom of the formwork with the subordinate cage resting on the main cage. Fig. 1, is a typical example of a subordinate cage crossing onto a main cage. 25 The top bars of the subordinate cage 105 are resting on the top bars of the main cage 110. The bottom bars of the subordinate cage 115 can either be resting on the bottom bars of the main cage 120 or may be left suspended if the subordinate cage is dimensionally smaller than the main cage. In a crossing situation, if a sequence installs a subordinate cage before installing 30 a main cage; the result would be a lot of unnecessary movement and adjustments to the main cage before the subordinate cage can be crossed properly. Similarly, a sequence installing a subordinate cage would also

interfere with the installing of a main cage in a subsequent sequence. We can thus see why it is so important to install main cages first before subordinate cages.

In the event that two subordinate cages have to be crossed, then subordinate cages in the same orientation or direction as the main cages will also be treated as a main cage.

The more important part of the planning sequence occurs here in Fig. 5, where the process 315 of assigning and arranging the sequences of packing and installation begins.

As shown in Fig. 5, the earlier detailed analysis of floor plan 410 is used to identify the loading bay 205 in Fig. 2 and also to identify main cages that are interconnected to each other. This loading bay 205 is an area within a construction site where all the precages for that construction site are to be placed prior to installation. The largest single free area will be selected to be the loading bay 205 as it must be big enough to accommodate the largest steel cage to be installed. When analyzing the required information 310 earlier, main cages have already been identified 425. In some instances, some main cages may be crossed linearly and interconnected end to end to form a continuous stretch of main cages 515, care must be taken here during assignment of cages to sequences. The general rule in this method is that the heaviest of the main cage in the stretch of main cages must be installed first. This will allow lighter main cages which are easier to handle to be linked up to the heavy main cage with less adjustments. Next, all cages are arranged in ascending order of weight 520; this makes it easier to compare the weights of the cages and help in achieving stable bundles. The more important main cages are assigned 525 to an installation sequence first, followed by the subordinate cages 530.

Referring to Fig 6, the detailed method of assigning sequences to install main cages are laid out. The principle behind the method is that each sequence of installation should install main cages that do not interfere with the installation of subsequent main cages. The assigning of main cages to the sequences should also be in descending order of weight. Each resulting

sequences should thus consist only of main cages that do not interconnect with each other. The first sequence should install the heaviest main cage, the next heaviest non interconnecting main cage and so on until all non interconnecting main cages are assigned to this first sequence. Subsequent
 5 sequences will result in lighter main cages being installed making installation easier if crossings and interconnecting of main cages are required.

Referring to Fig 7, assigning sequences to subordinate or non main cages is a relatively simple process. Unassigned subordinate cages are
 10 simply assigned onto the existing sequences that so far consists only of the main cages. A primary concern is that of proximity and ease of installation with minimal movement and maneuvering. The consideration for the heaviest main cage in each sequence decides which subordinate cages are assigned to that sequence.

The resulting sequences also translates into the resulting packing
 15 bundles. The bundles of stacked precages must be checked to ensure stability. The general rule in this method is that if cages are assigned or stacked in order of weight; with the lightest at the top and the heaviest at the bottom, the bundle is definitely stable. However, allowances can be made if
 20 heavier cages are stacked on top of lighter ones if the overall stability of the bundle is not compromised. Another concern is that of the height of resulting bundles. In the event that some of the bundles are too high, it may be necessary to reduce the height of the bundles by transferring subordinate cages between the other bundles. This will result in changes in the
 25 sequence, but as long as the subordinate cages do not interfere with the main cages, the installation sequences should still be able to flow smoothly.

To further illustrate the method of assigning the installation sequence of the precage, a simple example using an actual floor plan of an apartment in Fig 2 is used. The details of the reinforcing steel cages is shown below in
 30 Table 1.

Cage No.	Dimension (W x H x L) / mm	Weight / kg
T1	200x515x3000	29
T2	200x515x2600	27

T3	200x515x3280	38
T4	250x515x4700	86
T5	250x515x4700	155
T6	250x515x4800	88
T7	250x515x4700	61
T8	250x515x3600	35
T9	150x515x3580	52
T10	150x515x4500	69
T11	150x415x3100	29
T12	150x515x3180	33
T13	250x515x3180	42
T14	150x515x2480	24
T15	150x415x3800	38

Table 1

The required steel reinforcing cages are labeled T1 to T15. The main cages have been identified to be T4 to T8. The loading bay 205 as shown in Fig 2 is designated in the single largest area in the unit. Assigning main cages first resulting in 2 sequences;

1st sequence with main cages T7 and T5

2nd sequence with main cages T4, T8 and T6

Subsequently, the subordinate cages are assigned bearing in mind minimal movement and proximity to the heavier main cages. A third sequence was then added to facilitate the subordinate cages that crossed with main cages in the first two sequences. The cages are finally assigned into three bundles. Checking for stability of the bundles resulted in Bundle 2 having a main cage T8 installed before a subordinate cage T10. This arrangement is possible as the subordinate cages assigned to the sequences do not cross with the main cages and the stability of the entire bundle is preserved.

The resulting installation sequence/bundling is as follows.

Bundle 1 : T11, T15, T9, T7, T5.

Bundle 2 : T14, T8, T10, T6, T4.

Bundle 3 : T1, T2, T3, T12, T13.

This sequencing is only one of a variety of combinations that can result from the application of this method of planning and installing of precages 300.

With further refinement and adjustments based on the above result, other sequences could also be derived.

To further enhance the ease of installation of precages, this planning method can be further incorporated into the assembly process of the factory.

- 5 Once the installation sequences and the bundles have been determined, this information can be provided to the production planning system of the precage factory. Tags or labels can be attached to the completed precages which can then be stacked and packed into the bundles. In addition, the bundle themselves can also be tagged. This method of packing and tagging the
10 precages will significantly reduce the reliance on the skill level of the fixers and supervisors installing the precages.

The present invention therefore provides a method of packing and installing precages which overcomes, or at least reduces the above-mentioned problems of the prior art.

- 15 It will be appreciated that although only one particular embodiment of the invention has been described in detail, various modifications and improvements can be made by a person skilled in the art without departing from the scope of the present invention.

Claims

1. A method for packing and installing of precages in a work site, said site
5 including at least one set of formworks within which precages are casted
with concrete, the method comprising the steps:
 - a. analyzing and extracting information from detailed drawings and
floor plans for the work site,
 - b. determining a plurality of installation sequences for installing a
10 predetermined plurality of precages such as to ensure minimal
arrangement and re-sorting during unpacking of precages; and
 - c. translating said plurality of installation sequences into a packing
order resulting in a plurality of stable bundles of precages such as
to ensure rapid installation of precages without unnecessary
15 handling and adjustments and not requiring skilled personnel for
performing the said installation.
2. A method according to Claim 1 wherein said extracted information in step
a. comprises:
 - i. locations of a predetermined plurality of formworks requiring
20 precage reinforcement,
 - ii. dimensions and weights of required precages,
 - iii. crossing conditions of precages and
 - iv. matching of a plurality of main precages and a plurality of
subordinate precages,
25 said plurality of main precages providing main supports
and load distribution in the work site,
said plurality of subordinate precages being all other
precages not identifiable as main precages.
3. A method according to Claim 1 wherein the step b. of determining a
30 plurality of installation sequences for installing a predetermined plurality of
precages, is carried out by the steps:



- i. selecting a plurality of precages for assigning to a plurality of installation sequences,

said one of a plurality of installation sequences comprising:

5 a plurality of main precages not interconnecting with each other and not interfering with subsequent installations of a plurality of main precages of a plurality of subsequent installation sequences, and a plurality of subordinate precages in proximity to
10 the heaviest main precage of this installation sequence; and

ii. assigning of said plurality of precages to said installation sequences in descending order of weight such as to ensure minimal rearrangement and re-sorting during unpacking of
15 precages;

4. A method according to Claim 1 wherein the step c. of translating said plurality of installation sequences into a packing order resulting in a plurality of stable bundles of precages, is carried out by the steps:

i. reversing sequencing order in said plurality of sequences;
20 ii. checking said plurality of bundles ensuring stability whereby heavy cages are predominantly at the bottom of the bundle; and
iii. checking heights of said plurality of bundles ensuring that they are relatively similar.

25 5. A method according to claim 1 further comprising tagging of individual precages with information comprising:

i. precage nomenclature corresponding to formwork nomenclature;
ii. crossings with other cages if any,
30 iii. position of a particular cage in its own installation sequence and bundle.



6. A method according to claim 1 wherein incorporating said method into a production planning system such that resulting precages and bundles are tagged and packed, ready for transportation to installation site.
7. A method for packing and installing of precages in a work site, said site including at least one set of formworks within which precages are casted with concrete, the method comprising the steps:
- a. analyzing detailed drawings and floor plans for a work site in extracting information pertaining to:
 - i. locations of a predetermined plurality of formworks requiring precage reinforcement,
 - ii. dimensions and weights of required precages,
 - iii. crossing conditions of precages and
 - iv. matching of a plurality of main precages and a plurality of subordinate precages,
 - b. determining a plurality of installation sequences for installing a predetermined plurality of precages, steps comprising,
 - i. selecting a plurality of precages for assigning to a plurality of installation sequences,
 - said one of a plurality of installation sequences comprising:
 - a plurality of main precages not interconnecting with each other and not interfering with subsequent installations of a plurality of main precages of a plurality of subsequent installation sequences,
 - and a plurality of subordinate precages in proximity to the heaviest main precage of this installation sequence; and



- ii. assigning of said plurality of precages to said installation sequences in descending order of weight such as to ensure minimal rearrangement and re-sorting during unpacking of precages;
- 5 c. translating said plurality of installation sequences into a packing order resulting in a plurality of stable bundles of precages, steps comprising:
 - i. reversing order in said plurality of sequences;
 - 10 ii. checking said plurality of bundles ensuring stability whereby heavy cages are predominantly at the bottom of the bundle; and
 - 15 iii. checking heights of said plurality of bundles ensuring that they are relatively similar such as to ensure rapid installation of precages without unnecessary handling and adjustments and not requiring skilled personnel for performing the said installation.
- 8. A method according to claim 7 further comprising tagging of individual precages with information comprising:
 - 20 i. precage nomenclature corresponding to formwork nomenclature;
 - ii. crossings with other cages if any,
 - iii. position of a particular cage in its own installation sequence and bundle.
- 9. A method according to claim 7 wherein incorporating said method into a
25 production planning system such that resulting precages and bundles are tagged and packed, ready for transportation to installation site.

