PRECAST STAIRS FOR SELF HELP HOUSING

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ABSTRACT Precast stair of small components are more appropriate to self help housing, rather than insitu concrete stairs. A review of precast stairs reveal some shortcomings, thus an innovative stair is proposed. The proposed stair is more flexible and could be assembled with minimum skills while keeping high structural performance.

Introduction

The application of appropriate self build technologies has become a necessity due to the increasing high cost of conventional building. Traditional insitu concrete stair construction is one of the most difficult building operations, where it requires skilled labor and costs about 8 % approx. of the dwelling construction cost in Egypt (1). Therefore, stair construction have to be facilitated for self builders and small local contractors. It could be produced from available materials with limited resources, lightweight to be handled manually and simple enough to be assembled with unskilled labor.

The widely used insitu concrete stairs in most countries is made of either reinforced concrete slabs or cantilever steps supported by a stair beam. The building process depends on the use of temporary inclined shuttering and "tailored" steel bars, which is a time and material consuming operation. However, there is a simpler vernacular process, which has been applied for centuries, using ready made steps of stone, marble and lately precast Terrazzo.

This paper discusses the potentials of vernacular prefab stairs, its means of development, and reviews existing self build stairs. It concludes with a proposed innovative stair, that could make use of its advantages, while alleviating its shortcomings.

Potentials and development of vernacular prefab stair

Ready made vernacular stairs have many potentials of being low cost, speedy construction where no time needed for formwork and hardening of concrete, thus requiring less installation skills. Moreover, it is deeply rooted in the architectural heritage of many countries, therefore it won't meet technological rejection. Nevertheless, although these potentials that suit owner/builders and small contractors, this building process is not widely used nowadays, because of some technical reasons, which might be :

- low quality.
- limitations of the surface finishing to a "low-value status".
- heavy weight of the treads.

These shortcomings calls for development depending on :

- increasing the structural performance of components and joints.
- widening the range of possible finishing surfaces, or produce a "body" that accepts different sheets of materials.
- reducing the weight of the components, to be handled manually.
- facilitating the assembly process.
- the rational the use of material, specially steel, and the use of local materials such as reeds or bamboo.

Design of small components stairs

Prefabricated stairs could be made of either timber, steel, concrete or a blend of these materials. The scarcity and high cost of timber and steel, makes it more economical in most developing countries to use reinforced concrete components.
The selection of the structural system of the stair depends on the staircase plan, which determine shape and size of each component. Moreover, floor height dictates whether to be bridged by a single run of stairs, by a flight of stairs arranged to follow a straight or a broken line of an intermediate landing (2).
For low cost housing, the staircase area should be minimized by using a single run of stairs for family houses (Fig 1), while in block apartment buildings, it consist of two parallel flights.
Furthermore, the joints between stairs and floors require special details to fit each stair shape. It is preferred to arrange the stair parallel to the beams, where stairs are often supported by the walls and a spandrel beams. If the stair reached the floor level without direct joint to the wall or spandrel beam, a beam of adequate cross section should be constructed for this purpose (3).

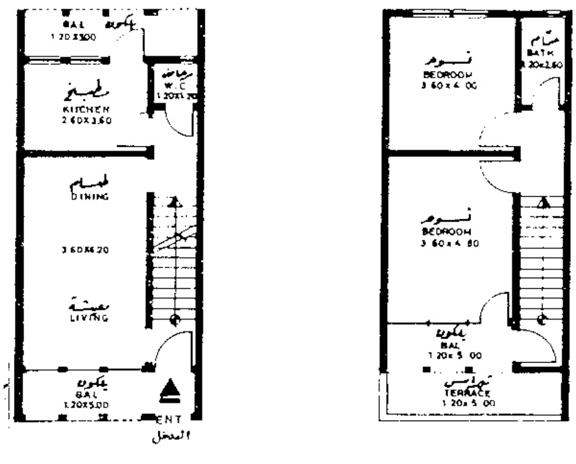


FIG.1 The use of single flight stairs.

Prefab types of small components' stairs:

1) Vernacular ready made stairs

This stair is usually made of stone, marble or reinforced terrazzo separate steps supported by the side wall (Fig 2). The intermediate landing is either a cross beam or a rectangular component supported by the same way. The advantages and disadvantages of this stair have been mentioned earlier.

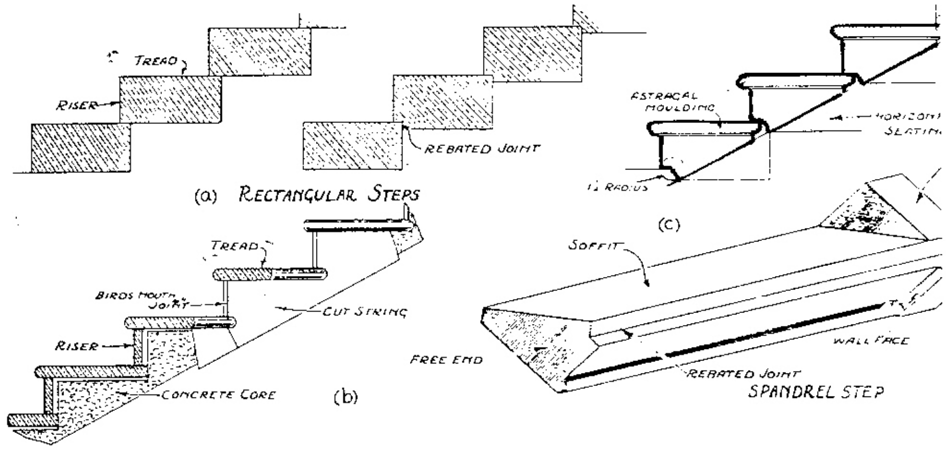


FIG.2 Details of a vernacular staircase (Warland, E. 1929)(4).

2) Prefab stair platforms (Chinese)

This is a modern version of the vernacular stair, which depend on the use of prefab RC "r" shape treads, that could be supported

either on one or two sides of the walls (Fig 3)(5). The "r" shape achieves the required supporting area, while reducing used material and weight of each step. The weight of each step is 55-60 Kg, thus, it could be easily lifted and placed in position by two laborers.
A survey in rural China has revealed its acceptance because (5):
- The lack of timber and viability of cement and steel.
- It is cost saving of about 30%, comparing to timber stairs.
- It is fire and "insect" proof.
- It has a higher sound insulation.
- It is more durable and free-maintenance.
- It is easily produced without considerable training.

However, the installation of steps inside the wall requires skills to achieve safety, special architectural details for the wall and other smaller blocks to fill the wall space under the steps.

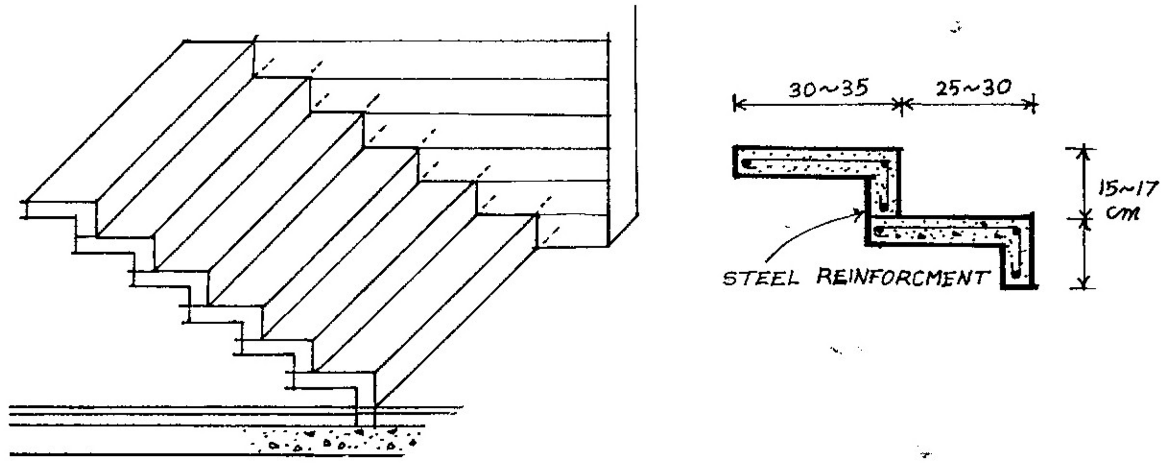


FIG.3 The Chinese platform stair (CBTDC 1989)(5).

3) Prefab treads supported on two walls (Jordanian)

The stair of the Jordanian Building System # 5 consists of two elements: the saddle which is placed between the block coarse of two parallel bearing walls, and the tread which is supported and bolted to the right and left saddles (Fig 4)(6).
The tread is provided with a steel angle on its edge to resist friction. The landing consists of similar modular element to the tread. The weight of the saddle and the tread is 17 Kg & 44 Kg (6).

There are other stairs similar to the Jordanian stair which apply the same concept of using sheet plates. The obvious advantage of this type is its lightweight, easy-build and high structural safety. However, it requires two parallel walls, which limit the architectural design and cost more because of the second wall.

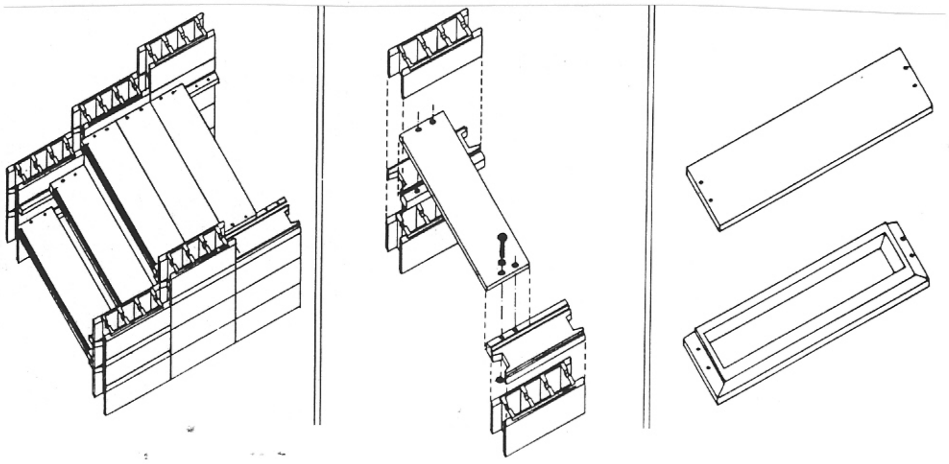


FIG.4 The Jordanian stair of Building System # 5 (RSC 1988)(6).

4) Prefab stringer beams and treads (Thailand)
This stair was developed for self build in South East Asia, as a low cost alternative to local wooden stairs. The stair consists of two stringer beams, precast treads and metal balusters (Fig 5)(7). Production and construction are facilitated, using simple wooden molds and easy manual handling. Bamboo reinforcement could be used to reduce cost by substituting the wire mesh in the treads (Fig 6). Although this stair is more versatile, it requires more production skills and accurate installation to assure its structural safety.

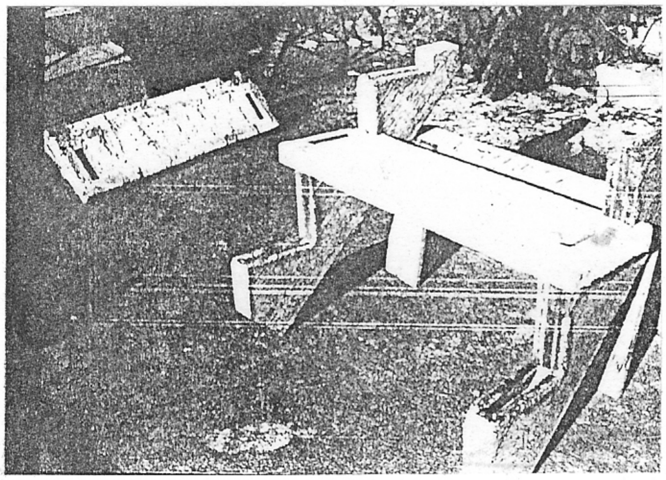


FIG.5 Prefab stinger beams and treads (Etherington 1984)(7).

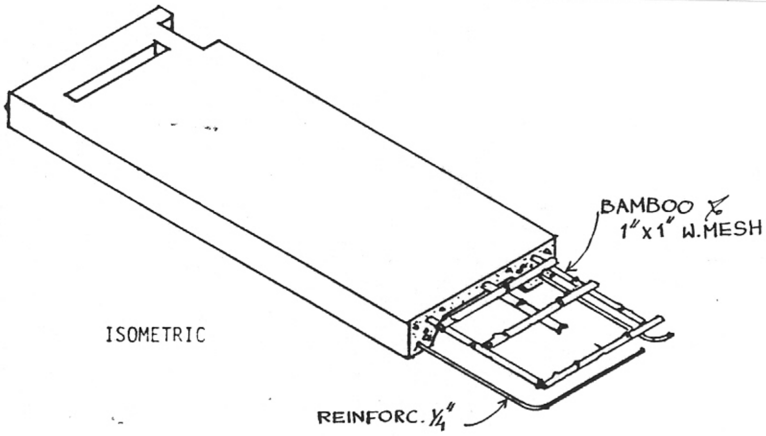


FIG.6 Bamboo reinforcing and construction of treads (7).

5) Modular linear stair units (British)
This stair consists of precast modular longtudenal reinforced concrete sections of 15 cm wide. It is manufactured of variable lengths up to 9 risers, to form a height of a half-story (Fig 7). Installing one flight stair is also possible by using an "L" shape intermediate beam supported from both sides. The components could be placed in its position manually by two unskilled laborers (8). This linear stair component concept is more flexible than the steps concept, where any width could be achieved as multiples of 15 cm. However, the one flight stair requires a structural support to carry the intermediate landing beam which restricts the design. Moreover, the stair can't be installed unless the floors and landings are installed already, which might need scaffolding.

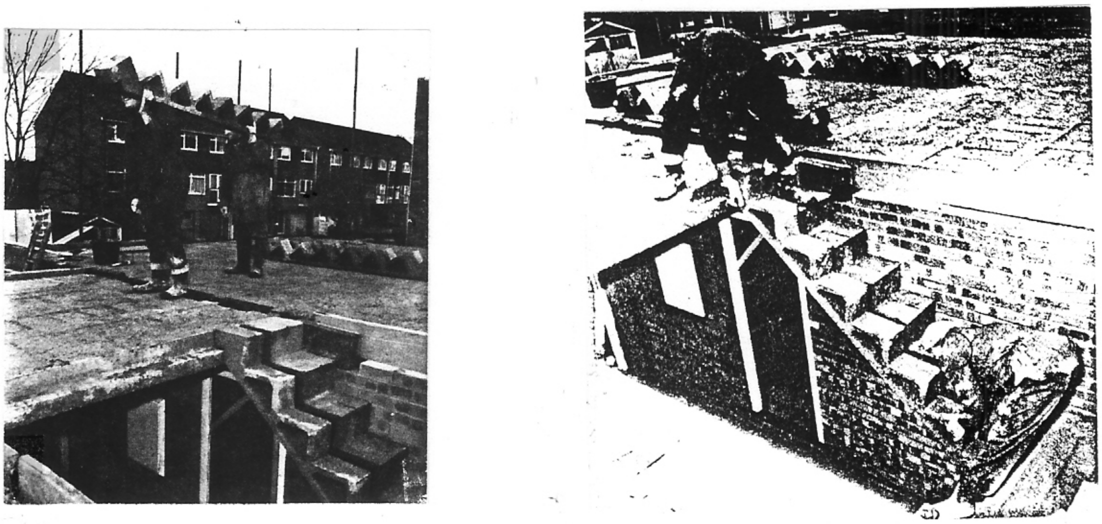


FIG.7 Application of the British modular stair component (8).

Proposed easy-build precast stair:
The reviewed stairs consist of several components, requiring different molds, more assembly time and relatively more skills. This has called the author to propose a "one component stair" that could be used with low cost housing projects. Because self build housing is usually of bearing walls, the stair would be integrated in the wall as one unit. The component is a reinforced precast step, projected out of the wall block (Fig 8). It applies the same structural theory of vernacular stairs, carrying the loads to previous steps, while firmly connected to the adjacent wall.
The wall itself is composed of a "T" shape standard 20x20x40 cm concrete blocks. The "T" blocks is designed to achieve a stair decline of 33, with a Flemish bond pattern, without vertical mortar, while keeping high structural performance (Fig 9).
The weight of each step/block component is 70-80 kg approx, which could be easily installed by two unskilled laborers.

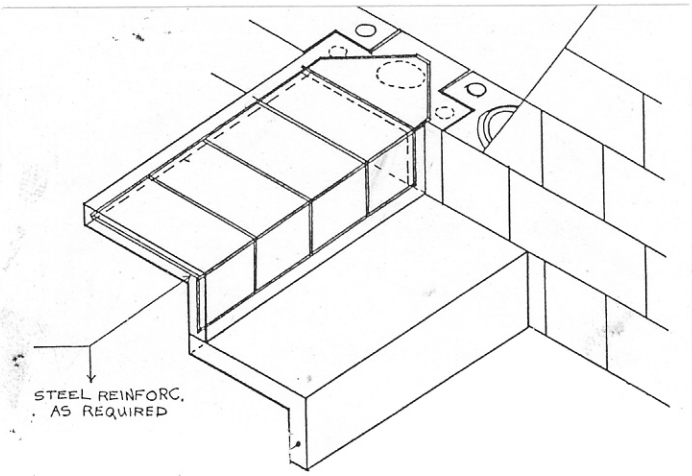


FIG.8 The proposed step/block component.

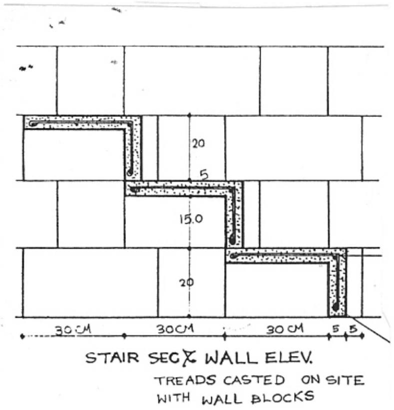


FIG.9 Stair section and wall pattern.

Production and building of the stair component:

The step/block component would be casted upside down in a flexible mould, by sliding the end of the mould closer or farther apart from the block (fig 10). Steel reinforcing would be placed in the mould, connecting the block to the step. The step/block would be stacked as a traditional bearing wall by two unskilled laborers.
The overlapping of each step on the previous one, would easily be achieved since the wall pattern guides block stacking (Fig 11).

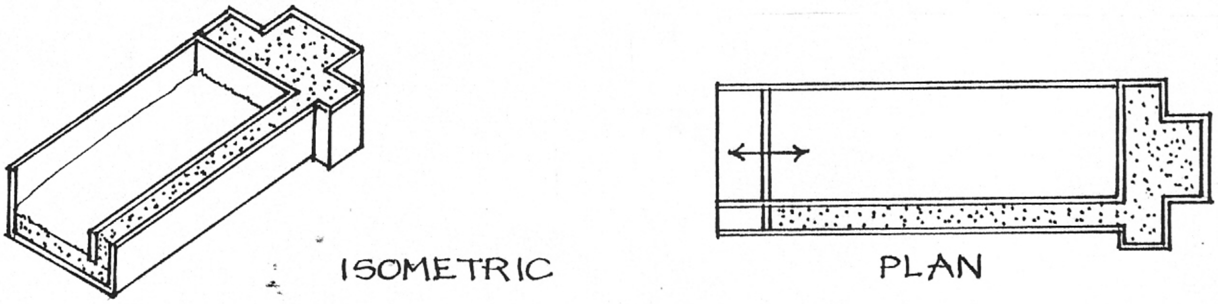
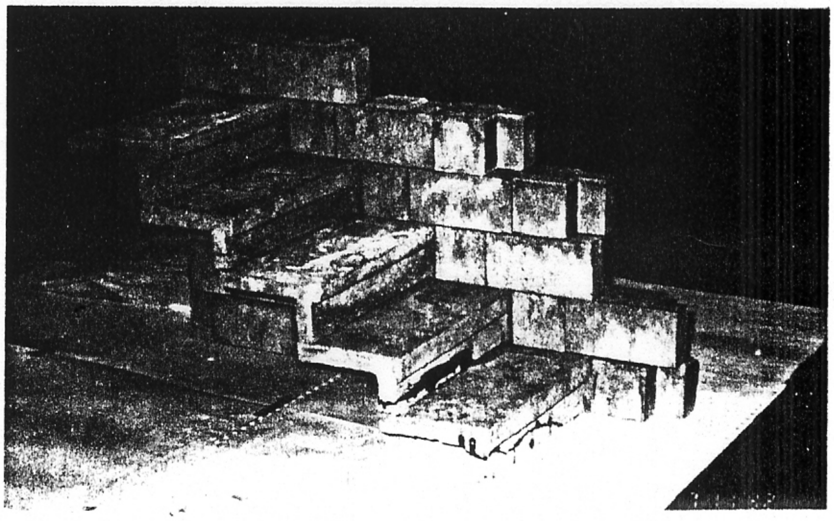


FIG.10 The mold of the step/block component.



(Fig 11) Photo of the step/block self build stair.
* Model was constructed by the author when he was a visiting scientist at Ohio state University in 1992

Advantages of the step/block stair:

- Producing one component is easier than producing many components.
- Installing one component minimizes unskilled laborers' mistakes.

- The structural performance of the step/block is higher than other self build stairs, even though it requires less reinforcement.
- The step/block stair does not require two parallel bearing walls, thus reducing the cost and architectural limitations.
- The component could be produced as a finished product using different sheets of materials, since it is casted upside down.
- Environmental materials could be used with steel for reinforcing.

The only restriction of the step/block is requiring a certain block and pattern of the wall. However it could be applicable only to the bearing wall of stair, not the whole building. The riser and tread dimensions could be varied if certain specifications are to be met.

Conclusion:

Although precast stair of small components have many advantages over conventional insitu concrete stairs -e.g. easier and speeder to build, less costly- they still have some shortcomings. They usually consist of several components, requiring different molds, more assembly time and some skills. Moreover, these stairs are either constrained in width, or in length. Therefore, one component stair was proposed, connecting the adjacent stair wall with prefab steps that could be casted in a flexible and simple mould on site. The wall itself depends on a standard "T" shape block, which doesn't require vertical mortar. The proposed stair could be built of different widths and lengths, with minimum skills while keeping high structural performance, as was seen from the early tests. This precast stair is registered in USA and Egypt.

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