

## Prefabricated Building Construction — The Use of Aluminium Alloy Formwork\*

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**Abstract:** The Wah Wui System Formwork is a newly developed system formwork for industrialised housing in Hong Kong. The aluminium alloy formwork has lots of advantages, and the adoption of it can ensure the quality of concrete and therefore enhance the quality of housing.

In this dissertation, the author introduces the design, materials of aluminium alloy formwork, and also the transportation, storage, installation, advantages and disadvantages of it.

**Keywords:** prefabricated building construction; aluminium alloy formwork; industrialised housing

**CLC number:** TU328

**Document code:** A

### 1 Introduction

The Wah Wui System Formwork is a newly developed system formwork for the construction of industrialised housing in Hong Kong. It consists of standard size aluminium alloy formwork panel in lieu of the traditional timber formwork. The concept of using metal formwork commenced from 17th century, however, it could not be widely developed due to its heavy weight and rusty surface once exposed to weather. Within the Asia Pacific Region, the common use of the aluminium alloy system formwork started from 1995 in Malaysia, later on in Taiwan and now widely used in Hong Kong. The standard size aluminum alloy formwork can be repeatedly used over 200 times in the construction. Both unskillful and semi-skill works can be easily trained to become skillful technicians. Detail designs are required if special shape for bay window, architectural features are drafted. For industrialised housing, it is recommended to use plain concrete walls, beams and slabs that may be more cost effective in construction.

### 2 Installation

1) The aluminium alloy system formwork consists of over 200 items, including standard panel and accessories with fine tolerances. The corner sections are designed for angle fixing and are easy to remove after casting of concrete. A special feature of the design is that it provides for removal of slab panels without disturbing the supporting props. A set of system formwork consists of a mould for the monolithic pouring of concrete walls, columns, beams, slab, staircase, and bay windows, etc.

2) The aluminium alloy sections are extruded or manufactured to an effective width and height that can be easily handled by a single worker. Consequently, the aluminium alloy formwork does not

\* Received date: 2001-03-01

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rely on heavy cranes or other heavy construction plant and equipment. However, the individual panels can be assembled together to form larger panels to minimize repeated dismantling and assembly, thereby saving cost, especially in the case of typical floors. All individual components of the system formwork can be connected by simple pins and wedges. The wall forms are removed 12 hours after pouring and for slab forms; the period is 36 hours after concreting. By means of Wah Wui aluminium alloy formwork, one set of system formwork can be repeatedly used over 200 times for a 5 days cycle construction.

### 3 Advantages

#### 3.1 Speed

The aluminium alloy system formwork allows 100% of the building (i. e. all internal walls, all external walls stairs, lift shafts, balconies, and sun hoods, etc.) to be constructed at a rate of 4 days per floor. This compares favourably with the traditional approach which will take at least 12 days a floor (for columns, beams and slabs only — then the infill walls have to be built and plastered).

As a result, the total structure is completed in a third to a quarter of the time required to build conventionally. Thus developers can make a reduction on project financing costs, and site overheads can also be significantly reduced.

#### 3.2 Quality

The flat, off-form finish produced by the aluminium alloy system formwork simply requires a 2—3 mm skim coat before decoration, thus eliminating the need for plastering (Often, clean plastering sand is scarce, and if poor sand is used, this leads to unraveling of plastered surfaces in a short period of time). In addition, all the elements of the building are accurately dimensioned, and are vertical, horizontal, and square in plan and section as intended, so that remedial works to correct inaccuracies can be eliminated.

As service collars can be accurately located and cast in as the slab concrete is being poured, leaks are eliminated. This is a major hidden saving as builders are very reluctant to admit (even to themselves) the true costs of locating and remedying leaks, often these tend to be covered by the 'contingency' figure.

#### 3.3 Safety

The props of the aluminium alloy system formwork are modified to form an integral part of the formwork system so that they do not need to be moved to release the slab forms — and therefore the repropping of the slab is not necessary. The elimination of repropping means the aluminium alloy system formwork is inherently safer to use on site than traditional formwork comprising timber and plywood, and any other systems that require re-propping after the removal of forms. In the event that 4 days per floor is expected, 4 to 5 sets of props are required.

#### 3.4 Elimination of Skilled Tradesmen

The aluminium alloy system formwork eliminates the need for skilled plasterers as noted above, and it also eliminates the need for skilled carpenters and blocklayers. Projects have often been seriously delayed because of the unavailability of these skilled trades.

#### 3.5 Cranage

Normally tower cranes are extremely busy especially when used for the vertical transportation of materials. It is a merit if crane is not required so often for the movement of the forms as the construc-

tion proceeds. Thus by using aluminium formwork, the crane is more available for concrete and steel placing and for lifting and transporting other materials. The crane is only required for moving the forms down from the top of the completed building.

### 3.6 Structure

The aluminium alloy system formwork allows consideration of a 'load bearing walls' structural design approach. A LBW design will always be more structurally efficient than a traditional reinforced concrete frame approach, and will give a very much stronger building. It will therefore be less expensive to construct as well as less expensive for the provision of the foundation.

Because the Wah Wui System Formwork is modular and flexible, it can be applied to any architectural or structural layout. Thus, the designers can be as creative as they like, and yet be confident that advantage can be taken of the system approach for construction.

### 3.7 Design and Shop Drawing

The aluminium alloy system formwork is extremely adaptable and flexible. It is rarely necessary to amend building design to accommodate the system. Based on the architectural and structural drawings of a proposed building, a process of computer modulation is carried out. This process requires that iteration and optimisation techniques are utilized to select the most economical and practical fitting of the individual components that comprise the system formwork. A large database containing all standard pieces of equipment is used in order to produce the shell drawing in a short period of time.

## 4 The Shop Drawing (s)

1) Once it has been decided to use the Wah Wui System Formwork for a particular project, the production of a Shop Drawing, based on the Architectural drawings with cross reference to the Structural Engineering drawings will be finished within 14 days and ready for submission.

In cases where some dimensional discrepancies occur between two supplied sets of drawings in the course of preparing the Shop Drawing, the designers will attempt to resolve these discrepancies with the agreement of both the Architect and Structural Engineer. This must be done prior to submitting the Shop Drawing to the Client for confirmation.

2) The Shop Drawing is the final dimensioned layout from which the design for the set of Wah Wui System Formwork is produced. The design of a set of formwork is an extremely intricate process, where separate consideration must be given to each and every detail required to create the building shape. Further, the shape and size of each piece of formwork relates to the shape and size of every other adjacent and opposite (in the case of vertical formwork) component. The levels of design complexity can be fully appreciated when it is comprehended that the holing pattern must be designed with assembly in mind this occurs in the same plane, at right angles and at other angles. Hence, it is necessary for at least two holes on each edge to match with the other adjacent panels, for the purpose of fixing.

3) Because an apparently small change in the layout will have dramatic 'knock-on' effect on the whole formwork design, it is better not to proceed with the manufacture process until the Shop Drawing is confirmed by the Client as 'Approved for Construction'. Confirmation of the Shop Drawing must be regarded by all parties involved as the end of the building design process.

4) If changes are insisted upon by the Client after confirmation of the Shop Drawing, there will be serious and unavoidable consequences; additional costs will be incurred and time will be lost against

the programme. Furthermore, changes insisted upon after construction has commenced and has the potential to cause a greater degree of, and can be very expensive.

#### (1) Material Package and Delivery

This is one of the important steps required to save labour in the erection. After manufacture, materials are packed on pallets in accordance with the numbering system assigned to facilitate easy location of panels so that they can be erected in the correct sequence. When the pallets are delivered to the specified location, the wall panels are erected according to the marking number as shown on the shop drawing. Different coloured lettering identify direction and location. Workers are normally instructed not to use differently marked panels even though they look similar; this will ensure fixing accuracy.

#### (2) Storage on Site

If the working level is not ready for erection, the pallet materials must be stored systematically with clear identity such that the required panel can easily be located and picked up for erection. Pre-planning of storage on site results in a good logistic support in the erection.

#### (3) Erection

Apart from the manufacturing process, the erection of the aluminium alloy formwork on site is an important step to put the planning into reality. It is vital to establish the daily construction cycle of work and then to co-ordinate and manage the other trades such as the fixing of steel reinforcement, followed by ducting works for electrical and mechanical installations and the placing of concrete. The Wah Wui Formwork System requires a disciplined and highly efficient working schedule that ensures other related trades will follow in a timely manner. This coordination of trades and the cycling of equipment at optimum speed results in buildings being constructed at rates of 4 to 5 days per storey as compared to traditionally expected rates of 10 to 14 days per storey without the removal of props as specified in the specification.

Due to the fine tolerances achieved in the machined metal components, accurate concrete forms and shapes can be obtained repeatedly, hence exacting standards can be achieved, thereby achieving quality and accuracy. This enables plumbing and electrical fittings to be prefabricated with certainty. The construction accuracy of the concreted works—with the barest of surface imperfections or blemishes, will also benefit other finishing trades such as tiling and the fitting of doors and windows.

## 5 Conclusion

The aluminium alloy system formwork encourages quality control from an early stage, i. e. from the planning and design stages, through the manufacturing process, packing, delivery to site, erection on site, dismantling and repeated assembly and removal process. In turn this facilitates good quality of concrete. The system has been proved to be successful in many countries and cities like Malaysia, Taiwan and Hong Kong. As the applicator of the aluminium alloy system formwork, I would like to say that further invention of semi-labour system by the use of construction R & D might resolve the intensive labour problem. It will take time to improve the design and erection in a more scientific and mechanical way in order to achieve an objective of using less labour.

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## 预制建筑施工工艺与铝合金板木的运用

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**摘要:**“华汇系统板木”是在香港特别针对住宅产业化而发展起来的新型系统板木,在香港得到了广泛的使用。由于具有多种优点,铝合金板木的采用有利于提高质量,当然,用它所浇筑的混凝土的质量也就得到了保证。

文中详细介绍了铝合金板木的设计、材料及运输、储存、安装和优缺点。

**关键词:**预制建筑; 铝合金板木; 住宅产业化

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## Chongqing's Preferential Policies for Investment in Housing Industrialisation

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**Abstract:** This article introduces the preferential policies for foreign investment in Chongqing and analyses and compares such policies. Then it puts forward suggestions based on the characters of industrialized housing so as to promote the industrialized housing in Chongqing.

**Keywords:** industrialised housing; policy; taxation; Chongqing construction industry; housing