

System analysis of technical and technological solutions of element connections in full-assembled construction in Russia and abroad

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ABSTRACT

Currently, there has been a significant trend and unique growth in the construction industry, especially in the sector of prefabricated structures due to various advantages, like price, as well as the speed of construction; therefore, new technologies can minimize construction time .

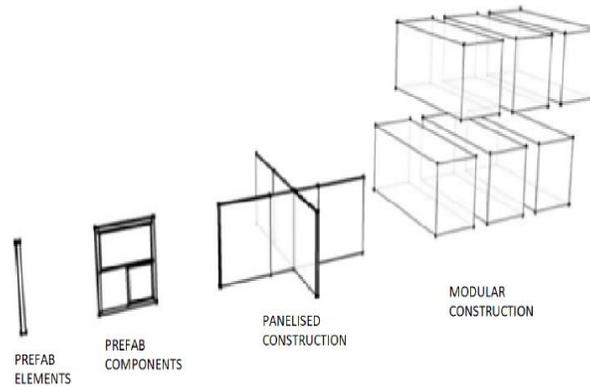
This article discusses the benefits of producing this type of structure, the most common types of joints utilized in it, and the technique of installation.

Keywords: Modular building, precast concrete structures, construction, prefabrication, precast connection

INTRODUCTION

Modular building is a building technology in which structures are extensively prefabricated off-site by the production of volumetric modular pieces. These room-size pieces are extensively prefabricated with high precision and then shipped on-site for quick assembly. Modular construction, as opposed to a single kind of structure, refers to the use of a range of structural systems and building materials [1]. Off-site manufacturing prefabrication can result in a shorter total construction timeline, higher quality, and less resource waste.

Prefabricated construction can be more readily applied to any pre-assembled element of a structure. Prefabricated construction can include any dry wall system, roof truss, plumbing system, etc [2]. Modular prefabrication is the most advanced, with the ability to complete up to 95 percent of the structure before it is installed on-site . In prefab architecture, modules are also one of the most definable industries. (See Fig. (1)).



(a)

(b)

Fig. 1. (a) Craning of a modular unit during the final assembly of the building
 (b) Degree of prefabrication in construction

Precast concrete structures, which may be split into three of building structures, namely, precast concrete wall-based structures, frame structures, and frame-wall combination structures [3], play an essential part in modern construction industries. The essential technology of these buildings, regardless of whether type, is the connection between components, which usually includes the connections of column-wall, beam-wall, column-beam, wall-floor, and so on. The overall performance of the connections, energy-consuming capacity, and economic performance are all important factors in these types of buildings. The materials used in modular building units can be categorized based on the primary structure, such as concrete, steel, or wood. GFPR (glass fiber reinforced polymers) has also been considers as a part of the new materials that are being tried in the developing market of modular construction .

TYPES OF PRECAST ELEMENTS

According to the information provided below, two primary types of precast concrete elements are used: (See Fig. 2)

i. Precast reinforced concrete elements:

These must have reinforcing bars and/or welded wire meshes inside the elements to give structural strength as required by the component, such as façade walls, beams, columns, slabs, stairs, and parapet walls.

ii. Precast pre-stressed concrete elements:

These shall consist of pre-stressing tendons within the elements to provide a predetermined force needed to resist external loadings and cracks such as hollow core slabs, beams and planks [4].



POD ELEMENT



PARAPET BEAM



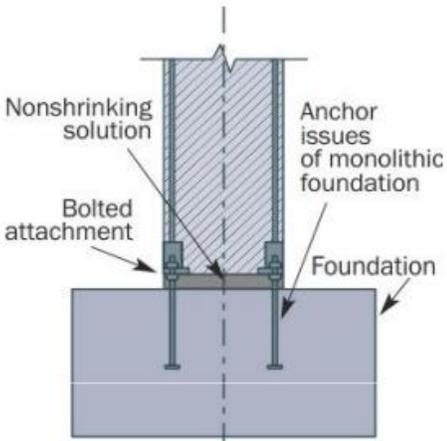
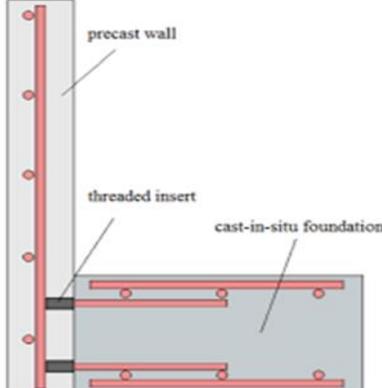
HOLLOW CORE SLAB

Fig. 2. Precast Concrete Elements

TYPES OF PRECAST CONNECTION ELEMENTS

In the prefabricated building, there are elements that are connected to each other[5,6], and each of them has a special methods of connection that are shown in table 1:

Type of connection	Example of connection	Method of connection
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<p>Column to foundation connection</p>		<ol style="list-style-type: none"> 1-Socketed connection 2- Bolted or base plate connection 3- Mechanical splice connections 4- Grouted connections
<p>Wall panel to foundation connection</p>		<ol style="list-style-type: none"> 1-Corrugated Duct 2- Grout Coupler 3-Precast Shoe
<p>Beam to column connection</p>		<ol style="list-style-type: none"> 1-The vertical member is continuous <ul style="list-style-type: none"> -hidden connections -visible connections 2-The vertical member is discontinuous <ul style="list-style-type: none"> -beam-ends resting on top of columns continuous -beams anchored at the head of the beams.

Column to column connection		1-Splice connection 2-Anchor bolt connections 3-Screw butt joint
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Table 1. TYPES OF PRECAST CONNECTION ELEMENTS

Connection types of precast concrete frame joints

There are some rules for joint design to ensure safety, such as that the components can resist ultimate design loads in a ductile manner, the precast members can be manufactured economically and erected quickly and safely, manufacturing and site erection tolerances do not negatively affect intended structural behavior, and are catered for in a ‘worst case’ situation, and the acceptable final appearance. In general, the choice of joint depends on the type and location of the structural elements to be connected. There are several types of joints, according to the following [7]:

(1) Wet connection joint :The wet connection combines the precast concrete components with post-cast concrete during assembling .In this system, a post-cast concrete includes a service hole, and U-shaped reinforcements are arranged at the end of the beam [8,9] . .(See Fig 3)

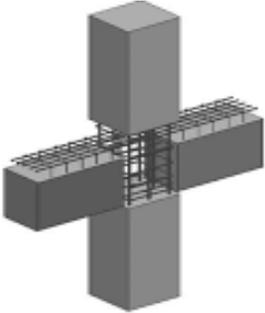


Fig.3. Wet connection joint

(2)Dry connection joints : Dry connection decreases the need for cast-in-place, which increases construction efficiency and eliminates environmental contamination. There are two types of dry connections: (1) welded connections [10], and (2) prestressed connections.(See Fig 4)

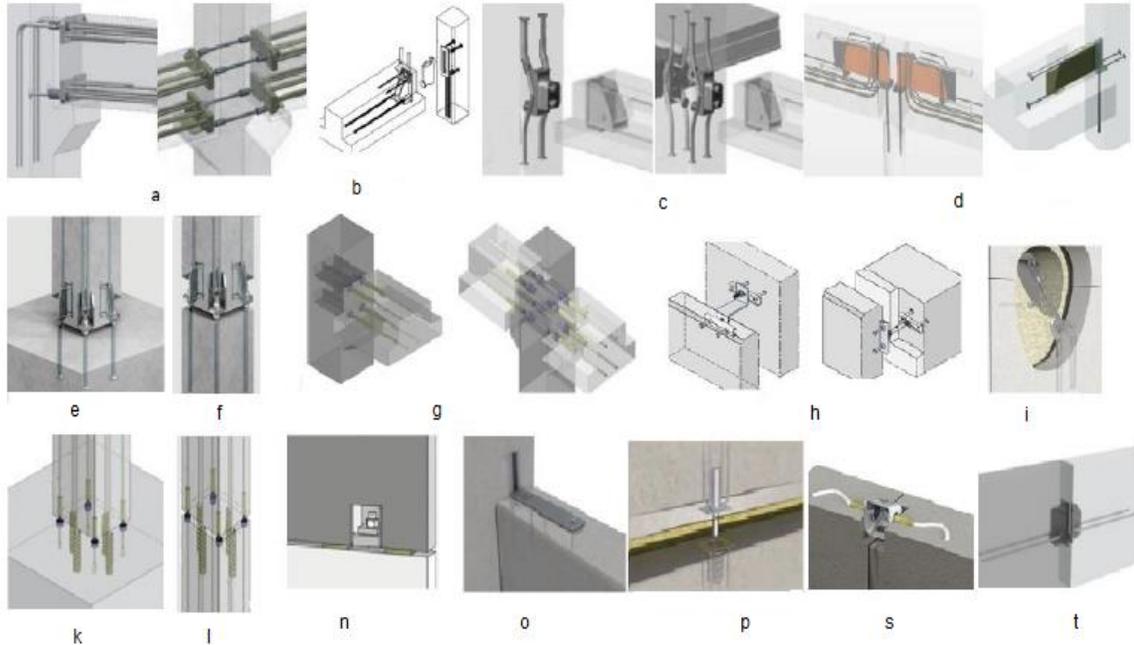


Fig.4. Examples of options for "dry" joints when using reinforced concrete elements: a - anchor-bolted beam-column; b — inserted beam-column; c - insert beam-column; d - insert beam-column; e — anchor-bolted column-foundation; f - column – column; g - anchor-bolted beam-column; h - anchor and bolt facade systems; i - anchor and bolt facade systems; k — anchor-bolted column-foundation; l - anchor-bolted column-column; n — anchor-bolted panel-panel; o - anchor-bolted panel-panel; p - anchor-bolted panel-panel; s - anchor-bolted panel-panel; t - snap-on panel-panel

3- PIN JOINTED CONNECTIONS

Pinned connections are typically called 'joints' because they include just one bearing surface. Frequently utilized in precast constructions because they may be constructed by element to element bearing in the simplest possible way. The precast design itself provides the possibility to build simply supported connections, in order to ensure that bending continuity between the various parts is avoided [11]. (See Fig. 5)

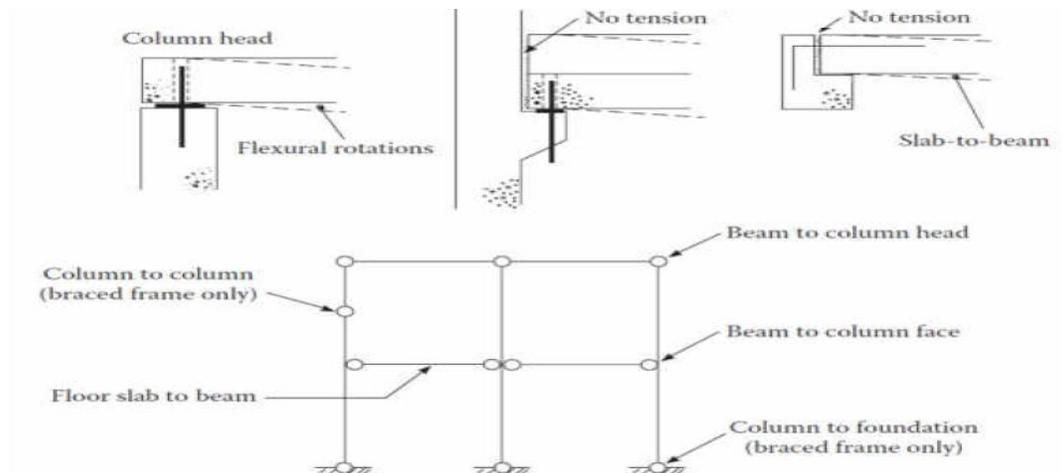


Fig. 5. Position of pin-jointed connections in structures

4-Pivot Hinges connection

Installation of a passive system includes zero-energy assembly mechanisms and precise control components, such as pivot hinges, which can be utilized to connect column to the floor or wall to others wall . This technique helps to speed up installation work since it is manufactured as a single unit in the factory and then opened and installed in its designated location on the work site [12,13].

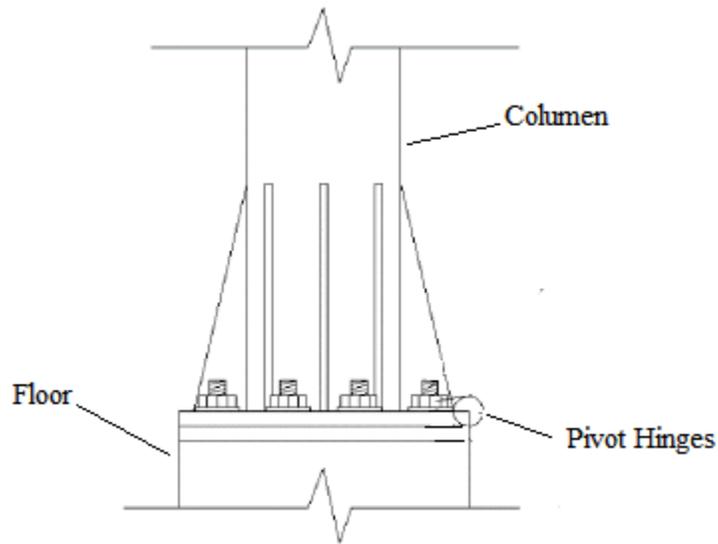


Fig.6. Using pivot hinges connection

CONCLUSION

Bringing modular technologies to the forefront of the modern building construction markets seems like a necessary evolutionary step towards a more efficient and productive industry. Strength, volume changes, ductility, durability (including fire and corrosion), easy for connection in fabrication structure, installation and maintenance, and loading conditions are all important factors in precast structural design.

The most important aspect of precast concrete structures is the connection. The connection transfers force between the precast components and determines the overall structure's strength, stiffness, and ductility. Failure of a single joint should not result in structural instability.

REFERENCES

- [1] P. J. Cameron JR and N. G. di Carlo, "Piecing together modular: understanding the benefits and limitations of modular construction methods for multifamily development", M.S. thesis, Massachusetts Institute of Technology, Cambridge, MA, USA, 2007.
- [2] R. E. Smith, Prefab architecture. A guide to modular design and construction. John Wiley & Sons, Inc. Hoboken, NJ, USA. 2010.

- [3] S. Velamati, “Feasibility, benefits and challenges of modular construction in high rise development in the united states: a developer’s perspective” M.S. thesis, Massachusetts Institute of Technology, Cambridge, MA, USA, 2012.
- [4] D. de Klerk, “Precast modular construction of schools in South Africa”, M.S. thesis, Stellenbosch University, Stellenbosch, South Africa, 2013.
- [5] Richard Henry, Yiquu Lu, Pouya Seifi, Tongyue Zhang, Lucas Hogan, Jason Ingham, Ken Elwood, LIGHTLY REINFORCED AND PRECAST CONCRETE WALLS:RECENT RESEARCH AND DESIGN RECOMMENDATIONS, Auckland Conference2016.
- [6] Zachry Construction Company. 21-Story Modular Hotel Raised The Roof for Texas World Fair in 1968. 2007. Available: <http://modular.org/HtmlPage.aspx?name=Hilton>
- [7] Sychev, S. A., Badin, G. M. Technologies for the construction and reconstruction of energy efficient buildings / - SPb .: BHV-Petersburg, 2017. - 464 p.
- [8] Yachao Zhong ^{1,2}, Feng Xiong ^{1,2}, Jiang Chen ^{1,2,*}, Ai Deng ³, Wen Chen ^{2,4} and Xulong Zhu ²,Experimental Study on A Novel Dry Connection for a Precast Concrete Beam-To-Column Joint, Sustainability, V. 11,1-23. ,2019.
- [9] Sergei Sychev, Industrial technology for assembling prefabricated transformable buildings in the Far North, Scientific-technical and industrial journal, 2017. No. 3, pp. 71–78.
- [10] Sychev, SA High-tech, energy-efficient and adaptive (robotic) construction systems in difficult construction conditions. Zhilishchnoe stroitel'stvo, no. - 2019. - No. 8. - P. 42–48
- [11] Kong Kian Hau,PRECAST CONCRETE CONNECTIONS , IES lecture in NUS university ,2018.
- [12] Sychev, S. A. Energy-economic house: Energy-Efficient construction technologies / G. M. Badjin, S. A. Sychev // Vol. 2, No. 1. Transmit World. – 2013.
- [13] Sychev, S. A. Technologies for fast economical construction of residential buildings / S. A. Sychev // ARPN Journal of Engineering and Applied Sciences. - 2015. –Vol. 10, No. 17. - P. 7502-7506.