Sustainable Urban Living Environment Through Prefabricated Buildings

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Abstract: The endless destruction of the natural environment and man's unbridled demand for natural resources has led to the spread of a series of environmental problems such as global warming, air pollution and land desertification. These environmental problems not only greatly restrict the development of the economy and society, but also threaten the living environment of human beings. With the change in people's living standards, people's demand for the urban living environment is also updated, and the sustainable development of the urban living environment is also a very important issue today. Some studies show that the energy consumption of building construction accounts for 35%-40% of the total energy consumption, and the high energy consumption of the construction industry is a global problem. The trend in urban construction today is to use prefabricated buildings, also known as assembly buildings, to promote the upgrading and transformation of the construction industry. Energy-saving and emission-reducing prefabricated assembly buildings will also be a trend in the industry in the future, and in the long run, the energy-saving rate of assembled apartments will be evaluated so that the degree of efficiency can be fed back to the relevant authorities to judge whether the assembled homes meet the requirements of sustainable development.

Key words: Prefabricated Buildings; Urban Living Environment; Sustainability

1. Prefabricated Buildings

Prefabricated housing is an industrialized production method to build houses. It is a house where some or all the components are prefabricated in a factory, then transported to the construction site and assembled by reliable connections. Prefabricated buildings began in 1830 when a carpenter in London, England, designed and built a house for his son to live in and shipped it to Australia (Blismas & Wakefield 2009). By 1960, only 15% of U.S. houses were portable prefabricated homes, but interest in the architectural design of prefabricated buildings has grown considerably since '90. Jean Prouvé was one of the pioneers of prefabricated houses, and his philosophy of construction responded to the technological changes of the first mechanical age with an economical and efficient pragmatism. Since the 1930s, Prouvé has been exploring the "prefabricated house", a key player in the transfer of mechanical mass production to practical construction, whether it be demountable barracks for the military during the war, emergency shelters for refugees, or assembled public buildings to house civilians after World War II, these prefabricated housing elements made of metal, often assembled in a day by a small construction team, provided an avant-garde solution to the post-war housing crisis.

Some research have shown that prefabricated assemblies can achieve 15.6% and 50% reductions in implied carbon consumption and implied energy consumption, respectively, in the material production process of prefabricated buildings. The environmental impact of prefabricated buildings manufactured in factories can be improved due to better productivity and quality control, and the energy consumption and emissions of prefabricated assemblies for on-site construction are reduced by 20-70%.

Concrete and steel are the main contributors to the energy footprint and carbon footprint of buildings, and Bonamente (2013) shows that both the carbon and energy footprints are reduced when the floor area of assembled buildings is larger. Faludi shows that if 25% of the cement in concrete is replaced by fly ash, total greenhouse gas emissions can be reduced by 11%-14%.

The development history of prefabricated assembled housing: relevant experts generally believe that the development history of assembled housing has gone through three main stages, the initial stage: which focuses on building an industrialized production system to meet the mass and rapid construction; the development stage: focus on improving the quality and cost performance of assembled housing; the mature stage: focus on the development of low-carbon and environmentally friendly assembled green housing, reduce residential material consumption, reduce environmental pollution, and solve the problem of residential diversity and personalization.

2. Urban Living Environment

With the rapid development of the economy, people gradually realize the importance of the urban living environment. The main factors affecting the urban living environment are water pollution and air pollution. Water pollution and water shortage lead to the threat to the urban living environment, generally through the system to build a better sewage regulatory system, through supervision to make each sewage production party more prudent production and discharge of sewage; from the engineering to building a better sewage treatment system to improve urban restoration capacity, as well as ecological restoration of the city and other measures to improve the urban living environment. Air pollution is also an important factor affecting the urban living environment. The main sources of air pollution are motor vehicle emissions, building construction and coal-fired heating are outdoor pollutions. By encouraging residents to use public transportation and energy-efficient cars, urging construction companies to adopt greener construction methods, and vigorously developing alternative fuels and clean energy sources, the urban living environment can be improved.

Residential buildings account for 13% of Australia's greenhouse gas emissions, a figure that is rising by 1.3% each year (Wood 2009). A residential building is socially designed to ensure that residents are provided with adequate comfort and quality of life during its life cycle, which also includes acoustic comfort, visual comfort, adequate comfort in rooms, and ease of use of public spaces and public facilities. The residential sector in the European Union statistics its energy consumption as 63% of the total energy consumption in the EU (Banaras, 2007). There has been a debate about sustainable urban living environments, and the book Sustainable Development and the City outline the advantages of high urban density due to increased public transport and reduced reliance on the car (Newman & Kenworthy, 1999). They advocate that planning should reduce facilities for car travel and that higher densities are needed to limit infrastructure, and they argue that road infrastructure is destroying the natural landscape (Vander & Cowan, 2007).

Janis (2002) discusses in Positive Development the paradox of high-density urban living, the reduction of car travel and nearby amenities can be associated with urban living sustainability, but there are many variables and contextual factors that obscure the truth about the impact on urban living environments. Urban living environment sustainability has been focused on density and situation, using zoning and land use to determine the style of buildings from a spatial planning perspective to achieve urban living environment sustainability and the most effective situation to make the urban living environment sustainable (Kendall, 1999).

3. Sustainability

The sustainability of urban living is related to the living environment and quality of life of every urban resident. Solving the sustainability of the urban living environment usually starts with various pollution problems of the urban living environment and often ignores the architectural aspects. Architecture is the biggest difference between the urban and natural environment, almost all the problems in urban life are related to architecture, and the solutions we are struggling to find are also hidden in architecture.

In the discussion of the urban living environment air pollution is an important factor affecting the urban living environment, building construction is an important source of air pollution, to achieve sustainable development of the urban living environment can be taken from the construction side, with prefabricated buildings to achieve sustainability of urban living environment has a practical significance that can be discussed. Contemporary innovative prefabrication technologies should be inseparable from the concept of sustainability. Today, ecological awareness is growing. That is why solutions with the least negative impact on the natural environment are sought in architecture.

Jim showed that modular buildings can reduce construction waste by 2.5 times, energy consumption by 5% and production time by 5 days compared to similar conventional buildings. Cao showed that buildings with 38% prefabrication can reduce resource consumption by 35.82%, health damage by 6.61% and ecosystem damage by 3.47% compared to buildings with zero prefabrication. Other studies have shown that assembled buildings have advantages over conventional buildings in terms of waste generation, greenhouse gas emissions, and on-site noise and dust pollution. Silva Pedro (2013) advocates near-zero energy buildings, hoping to minimize the energy consumption and waste emissions of buildings, and on this basis proposes innovative retrofit measures for the construction of facades of assembled buildings.

Several other studies have shown that benefits can be obtained by replacing or supplementing traditional on-site construction with prefabrication methods. These benefits include faster construction time, greater energy and economic efficiency, safer fabrication, and superior quality and performance. In the face of the damage to the environment caused by traditional building construction and the continued downturn in the real estate market, as well as energy-saving and environmental protection policies, traditional building production methods are facing a major bottleneck that the real estate industry urgently needs to address. The real estate industry needs to change from crude production to intensive and refined products, and to green, healthy and sustainable prefabricated assembled houses. Automated manufacturing of factory prefabricated components can optimize resource consumption and thus reduce waste. One of the foreseeable opportunities for the development of prefabrication technology is to reduce the weight of components and increase the share of recycled materials, including the use of scrap from prefabricated manufacturing and the recycling of industrial by-products.

Kiebert's book outlines six principles of sustainable building.

1. Reduce resource consumption
2. Reuse resources
3. Use recyclable resources
4. Protect nature
5. Life cycle costing
6. Quality treatment of materials and surfaces

The advantages of using prefabricated buildings are as follows.

(1) Improvement of residential quality

The quality of traditional cast-in-place housing is highly dependent on the quality of construction personnel's character and professional skills, and these human factors are likely to cause quality defects such as cracking and leakage in the housing. Mechanized production of the components in the factory, automated procedures to control the production process, to ensure the quality of the production of components, effectively avoiding quality defects caused by human factors, the construction site only requires professional installers to cooperate with the lifting, assembly components, construction processes from complicated to simple, to ensure the quality of housing.

(2) Energy saving and environmental protection

With the requirement of sustainable development, the low utilization of resources and environmental pollution brought by the traditional cast-in-place housing construction mode can no longer be ignored. The assembled housing construction mode reduces the on-site construction process and transfers a large number of component production to the factory, which not only reduces construction dust and noise pollution but also saves energy by about 30%, water by about 36% and materials by about 70%. The assembled house construction mode is consistent with the concept of sustainable development and is a new carrier of green building.

(3) Shorten the construction period

Traditional cast-in-place housing is wet-worked at the construction site, which is dependent on the weather, and the process of cast-in-place concrete is cumbersome, and the maintenance time leads to the delay of subsequent construction operations, which directly affects the project schedule. The factory production of assembled houses reduces the wet work construction on site, reduces the maintenance time of cast-in-place concrete, and reduces the impact of continuous bad weather such as heavy snow, rain and high temperature on the construction progress. Only professional installers are needed to lift and assemble the components at the construction site of assembled houses, which reduces the tedious process of cast-in-place concrete. The production of assembled housing components can be synchronized with the on-site assembly construction, and the multi-dimensional space can be operated in parallel to improve the efficiency of housing production, which can save about 31% of the construction period and achieve the purpose of shortening the construction period.

(4) Reduce construction costs

Traditional cast-in-place homes are wet-operated at the construction site, investing a lot of formworks, scaffolding and labour, increasing construction costs. In contrast, the components of assembled houses are mechanized and produced on a large scale in factories, which not only reduces the loss of materials but also reduces the amount of on-site formwork and scaffolding. The construction site of assembled houses only needs installation workers for lifting and assembling components, which can reduce the number of on-site labour and lower labour costs. At the same time, the flatness of factory-produced components is high, which can eliminate the plastering process in traditional cast-in-place housing and save labour and materials. Currently, labour and material costs are high, and the advantages of forming a scale system of assembled houses to reduce construction costs will become increasingly prominent.

In summary, the use of prefabricated buildings allows urban living environments to meet the following sustainability requirements.

Reduce implied carbon emissions by leveraging recycling and retrofit renovation opportunities and prioritizing recycled, low-carbon, durable building materials and construction methods. We minimize carbon emissions at all stages of the operational process and mitigate subsequent efforts to offset carbon emissions. We also employ circular economy solutions to further reduce carbon and waste generation throughout the building's life cycle. Integrate the needs of building occupants, including daylight, sleep shading, air circulation, views, temperature, sound insulation, and the smell and feel of healthy building materials. Prefabricated buildings not only help mitigate the environmental crisis but also help create the new green jobs needed to transition to a low-carbon economic model. Integrating whole-life costs including implicit carbon emissions, in-use carbon emissions, and overall operations, the use of flexible and durable buildings contributes to the local economy over the long term.

4. Conclusion

The above discussion reveals that prefabricated assembly buildings are an important means of sustainability in building construction, and the use of prefabricated buildings in urban residential housing enables the sustainable development of urban living environments. In future discussions sustainable methods can be adopted from other aspects of prefabricated buildings, such as the use of clean-fueled vehicles and close suppliers of precast concrete components, to optimize the environmental performance of assembled buildings.

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