STEEL SOLUTIONS IN THE GREEN ECONOMY

Affordable social housing
Introduction
More than half of all steel produced worldwide goes into buildings and infrastructure.

Sustainable steel housing
Research demonstrates that there is a link between the level of development of a region and its use of steel.

Altos Hornos de Mexico - ACERHOGAR
For example, in developing regions steel used in construction and infrastructure represents around 60% of overall steel use while in developed areas it accounts for only 35%.

ArcelorMittal - PROTEA®
According to a United Nations report, World Population Prospects: The 2012 Revision, launched in June 2013, the current world population of 7.2 billion is projected to reach 8.1 billion in 2025 and 9.6 billion in 2050. Population in developing regions is projected to increase from 5.9 billion in 2013 to 8.2 billion in 2050. During the same period, the population of developed regions will remain largely unchanged at around 1.3 billion people.

Tata Steel - NEST-IN
According to UN Habitat, by 2030, about 3 billion people, or about 40% of the world’s population, will require proper housing and access to basic infrastructure and services such as water and sanitation systems.

Sustainable steel housing in a life cycle perspective
This population growth will be accompanied by rapid urbanisation. In the 20 year-period, from 2010 to 2030, the population of urban areas is projected to increase by 42% and reach 5 billion. This means that in 2030 the world urbanisation level may reach 60% compared to 52% in 2010. The process of urbanisation will be largely driven by the developing world while the developed world will experience only an incremental increase.

The need for non-residential buildings (schools, offices, shops and manufacturing facilities) and related infrastructure will also continue to grow.

Many of the challenges posed by population growth, urbanisation, poverty reduction and mitigation of natural disasters can best be met by steel.
Steel use by sector in 2013

Steel is central to the evolution of society and the possibilities for using steel in buildings and infrastructure are limitless.

Steel housing is part of the solution for families in need of a shelter at low cost both in urban and rural areas across the world.

Due to its intrinsic properties of versatility, durability and strength, steel is a material of choice for not only the construction of skyscrapers and residential housing, but is also a key material component for the construction of affordable housing.

Steel houses can be assembled quickly and efficiently in all seasons. A house can be erected in a matter of days. Components are pre-manufactured off-site with minimal on-site labour.

Structural steel’s lighter weight relative to other framing materials such as concrete enables a smaller, simpler foundation.

These efficiencies in execution translate to considerable resource efficiencies and economic benefits, including accelerated project schedules and reduced site management costs.

Steel housing complies to all sustainability criteria: economic, environmental and social. A complete overview is available in diagram format on the last page of this publication.

Worldsteel members are engaged in sustainable housing projects in different regions of the world.

Three successful projects are described in this publication:

- ACERHOGAR: Altos Hornos de Mexico, Mexico
- NEST-IN: Tata Steel, India
- PROTEA®: ArcelorMittal, South Africa
ACERHOGAR houses consist of modular prefabricated parts assembled on-site, with a minimum amount of tools necessary. The fabrication does not require on-site welding.

The components are purchased in a package. Each package contains all the parts required to assemble one module, excluding the walls which are typically locally sourced.

The houses are of high quality and compatible with many materials used for the walls, e.g. cinder-bloc, brick and adobe, cement board, gypsum board, etc.

ACERHOGAR is an innovative self-construction system for affordable homes that can grow gradually according to the users’ needs. The system targets the poorest socio-economic levels of the population, and can be built in disaster and inaccessible areas.

The houses are solid, making it difficult for intruders to break in. In areas where a sense of insecurity prevails this can reduce stress and anxiety and improve quality of life.

The ACERHOGAR system was developed by Altos Hornos de Mexico, the largest steelmaker in Mexico through Nacional de Acero (NASA), a subsidiary responsible for marketing added value steel products.

Modern and modular
These days, a building’s function can change dramatically and rapidly. A house owner may want to make changes that increase floor space significantly. Walls may need to be repositioned to create new interior layouts based on different needs and space usage. Steel-built structures can cater for such changes.

There are different module options, according to each client’s needs:

- Master module 1 (4 x 6.2m)
- Master module 2 (4 x 8.2m)
- A module (3 x 3m)
- B module (3 x 3.6m)
- C module (3 x 4m)

The houses are specifically designed to expand as the family grows, and extensions are possible at any stage of home construction. A family can start with one module and add on later the number of modules required to complete the house.

Planning is easy and accurate, thus allowing for material leverage and workforce optimisation.

Rainwater can be recovered from the slab roofs into a steel tank with a water inlet directly into the house.

Affordable solar water heaters are also available which allows considerable energy savings.

Because of steel’s strength, lightweight, flexibility and ductility, structures made of steel are proven to best withstand natural disasters such as earthquakes and hurricanes.

Endlessly recyclable
Steel can be recycled infinitely with no loss of inherent properties. When a steel-framed building is demolished, its components can be reused or remelted in the steel industry’s closed-loop recycling system. Nothing is wasted. Thanks to its magnetic properties, steel can easily be separated from waste streams enabling higher rates of recovery than all comparable materials. Steel saves on the use of natural resources since a significant proportion of today’s new steel is already being made from recycled steel. Globally, recycled steel accounts for approximately 30% of new steel production.
The possibilities for using steel in construction are limitless

The most common applications are:

1. **Structural sections**: these provide a strong, stiff frame for the building and make up 25% of the steel use in a house.
2. **Reinforcing bars**: these add tensile strength and stiffness to concrete and make up 44% of steel use in house construction.
3. **Sheet products**: 31% is in sheet products such as roofing, purlins, internal walls, ceilings, cladding, and insulating panels for exterior walls.
4. **Non-structural steel**: steel is also found in many non-structural applications in houses, such as heating and cooling equipment and interior ducting. Internal fixtures and fittings such as rails, shelving and stairs are also made of steel.

Lighter with less impact on the environment

Steel structures can be significantly lighter than other building materials used for the same purpose and require less extensive foundations, which can result in dematerialisation. For example, 1kg of steel is sufficient to clad almost 9 times the area of 1kg of roof tiles.

Prefabricated materials are delivered on-site:
- reducing transportation and fuel use as less material is required
- minimising waste, on-site storage and noise pollution
- and making building sites clean, safe, dry and dust-free.
The houses are protected against corrosion and are UV resistant. Extension kits, rainwater systems and photovoltaic panels are optional. The surface area ranges from 12m² (shelter) to 100m² (residence).

Key features
ArcelorMittal complies with local construction regulations in countries where the structures are erected.

- Assembly is kept simple by using screw connections only.
- An installation guide is provided, making the installation fast and easy.
- The components, prefabricated in factories, are packed conveniently in protective containers and delivered on site ready to be assembled.

Wind resistant: The PROTEA® house is able to resist to winds up to 36m/s (130km/h) with peaks up to 50m/s (180km/h).

Seismic resistance: Steel is known to perform well in the event of an earthquake. Natural disasters with a large numbers of casualties are mostly associated with structures made from other materials.

Wind and cyclone resistant
Steel's strength enables houses to withstand strong wind. With the number of natural disasters on the increase, this is a crucial advantage. Extensive testing, calculation and standards for steel structures, have provided the industry with a thorough understanding of how steel buildings respond to the strongest wind loads, for high and mid-rise buildings, as well as for the low-rise and affordable residential buildings.

Fire resistance: The Council for Scientific and Industrial Research in South Africa performed a fire resistance test on the 60mm wall panel, with a 15mm Firestop plasterboard on the exposed side. The PROTEA® complex achieved a Fire Resistance Rating (FRR) of 30 minutes.

Light-weight and flexibility: Steel structures are generally lighter than those using other materials. Some steel structures are sufficiently light so that seismic design is not critical. Steel structures are generally also more flexible than other types of structures. Pressure on the structure and its foundations are therefore lower.

For protection, all windows can be equipped with anti-intrusion bars.
Earthquake resistant

Earthquakes are unpredictable in terms of magnitude, frequency, duration, and location. Steel is the material of choice for design because it is inherently ductile and flexible. It flexes under extreme loads rather than crushing or crumbling. Many of the beam-to-column connections in a steel building are designed principally to support gravity loads. Yet they also have a considerable capacity to resist lateral loads caused by wind and earthquakes. In their entirety, these connections provide superior reserve strength and defence, increasing a building’s resistance against earthquakes and potential for repair.

End-of-life

The PROTEA® wall and roof panels are insulated structural steel panels, which are designed for interlocking to ensure good insulation. The polyurethane used in these panels can be easily separated from the steel. The sandwich panels are shredded using a rotary shear and the material is then passed through a magnetic drum to separate the steel from the polyurethane. Alternatively, reusing the sandwich panels at the end of the house life could be a much simpler and cheaper solution of recycling.

Tata Steel has developed a light gauge construction solution which opens up new horizons in the application of steel in construction of affordable houses in India. This construction solution is being offered under the name, NEST-IN.

NEST-IN is a light gauge steel frame construction solution made of galvanised steel which offers high seismic resistance. It has been developed through the combined efforts of the Global Research & Development and Marketing team of Tata Steel, India.

NEST-IN house sizes range from 10 to 70m². Construction is very quick, as a 32m² house can be built in just 9 days, against a few months required for a conventional brick and mortar house.

Constructions are comfortable, durable and very attractive as they are made of an optimum combination of steel and non-steel material, giving them a conventional look and feel. The walls are thermally insulated and provide effective protection against outside weather.

NEST-IN is ideal for varied applications like houses, farmhouses, shops, medical clinics, banks/cash machines, community centres, courtyard shelters, site offices, guard huts, store rooms, classrooms, barracks, etc. and has the potential to replace the conventional method of building houses using brick and mortar. Moreover, the steel used in the house is 100% recyclable.

NEST-IN is eco-friendly as the construction process is almost dry and does not waste resources or pollute the environment as much as conventional building methods do.

Energy efficient

Steel is energy efficient, as heat radiates quickly from steel roofing, creating a cooler home environment in hot climate areas. In cold climates, double steel panel walls can be well insulated to better contain heat.
Key features

Framing system: The NEST-IN structure is erected by joining sections, using patented ‘Dipple Klick’ technology. This reduces the number of nuts and bolts needed.

Roofing system: The roof is made of Tata Shaktee roofing sheets, placed upon equidistant purlins in the truss. Ample numbers of trusses are provided in case of triangular roofs and have the ability to survive high wind pressure and speed.

Wall insulation: The walls of the NEST-IN structures are insulated using high quality insulation wool with a thickness of 50mm to 100mm, and a density of 32kg/m³ to 48kg/m³ depending on the design. This makes the house comfortable to live in, as the insulation reduces the heat exchange between the interior and exterior environment.

Wall panels: The walls are made of cement bonded particle board on both the external and internal sides which makes them smooth and strong. Moreover, the walls are plastered using polymer on the exterior and high quality wall putty on the interior. The use of polymer eliminates the need for painting the external walls and the colour doesn’t change over time. The wall boards are fire and water resistant.

Maximum use of space

Steel’s ability to maximise space and internal width with the thinnest shell possible means thinner, smaller structural elements are achievable. Wall thicknesses can be thinner because steel’s strength and excellent spanning capacity means there is no need to build space-consuming brick walls. This can be particularly relevant for heavily constrained sites, where steel’s space-saving properties can be the key to overcoming spatial challenges.

The construction process

Day 1 and 2: Laying the foundation
Day 3: Ring beam foundation
Day 4: Wall structure and truss building
Day 5: Roofing and external wall board
Day 6 and 7: Wall insulation and internal wall board
Day 8 and 9: External polymer rendering and internal wall finishing
Sustainability aspects

Economic
Steel housing is an affordable solution. Less material is needed to make a quality structure, and smaller foundations are required.

Steel is lightweight compared to many other building materials used for the same purpose, which can result in dematerialisation. Less material use and less transportation will lower overall building costs.

Steel products have long lifespans and can be used to create adaptable spaces or to add volume to extend the life of existing buildings.

Environmental
As steel building components can be cut to precise specifications or prefabricated off-site, on-site waste is minimised. Any steel scrap generated can be directly recycled in the steelmaking process.

Eventually, however, most buildings will be decommissioned. Reusing or recycling building components is key to the sustainability of a structure’s end-of-life, as it is the most economical and ecological solution.

Social
The social impact of steel modular houses is crucial. The houses are affordable and offer a quality and comfortable solution to deprived families in need of shelter. A basic house can be erected in days. Modules can be added on to cater for growing families.

Their resistance to earthquakes and high winds make them more comfortable to live in and enable them to last longer.
Sources

1 worldsteel estimate, 2014.

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