

Clothing factory in Sri Lanka



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Step by step

By Professor Dr. Hansjürg Leibundgut, Professor of Building Services at the Institute of Building Technology, Swiss Federal Institute of Technology (ETH Zurich), and member of the Technical Competence Center (TCC) of the Holcim Foundation

There are countless definitions of sustainability. Many are based on the three-pillar model: a project is considered sustainable when it responds equally to economic, ecological, and social factors – which often can be measured only subjectively – and brings these into lasting balance.

Balance. That sounds desirable. But we all know that it is often very difficult to achieve balance in practice; we are usually forced to weigh and trade off various interests. But even then we can produce notable achievements, certain aspects of which might even be exemplary.

In this publication the Holcim Foundation for Sustainable Construction presents a new clothing factory at Thulhiriya in Sri Lanka, the production site of an international clothing maker. The first phase of this building was finished mid-2008. I visited the factory a few months later and quickly recognized that this exemplary project also has its weaknesses.

For example, one could have covered the entire roof with photovoltaic panels. Columns in the halls could have reduced steel consumption. The aluminum roofing represents a significant amount of gray energy. Perhaps they could have avoided reshaping the pond on the site, and damaging flora and fauna by dredging.

One could have done many things differently. But still, the factory is impressive – also in terms of sustainability. As an engineer I have seen uncounted industrial buildings in my lifetime, but no project has impressed me as favorably as this two-story building.

Passive cooling reduces energy consumption. A hydroelectric plant supplies 90 percent of the power requirement, and photovoltaic panels cover the

“The people have created not just a building but a system – not a perfect one, but, measured on the imperfect scale of sustainability, a very good one. And that in itself is an outstanding achievement.”

rest. Once the final wing is constructed, the factory will give 1,300 people work – in a country beset by tsunami and civil war. Despite limited resources, much has been done with this building to enhance its sustainability profile.

When I think back on my visit, I remember women of Sinhalese and Tamil descent working together in groups. I see happy young people before me, pouring out of the sewing halls to enjoy lunch together beside the pond.

The surroundings of the pond are thickly vegetated again; no signs remain of the shovel excavator that enlarged it. The recuperative capacity of nature is so strong here that even massive interventions are not so decisive as in other global regions; accordingly, they must be assessed differently than elsewhere.

I am impressed by the commitment of the people who have created not just a building but a system – not a perfect one, but, measured on the imperfect scale of sustainability, a very good one. And that in itself is an outstanding achievement.





Sustainable construction

Quantum change and transferability

Ethical standards and social equity

Ecological quality and energy conservation

Economic performance and compatibility

Contextual response and aesthetic impact

Sustainable development and architecture are multifarious subjects intertwined with many other complex issues. To make sustainable construction easier to understand, assess, and practice, the Holcim Foundation for Sustainable Construction developed a five-point definition.

These five so-called “target issues” serve to measure the degree to which a building contributes to sustainable development. Three of the five target issues align with the primary goals of the Rio Agenda: balanced environmental, social, and economic performance. A further target issue applies specifically to building – the creation of appropriate buildings, neighborhoods, towns, and cities. The final target issue recognizes the need for significant advancements that can be applied on a broad scale.

These five target issues are explained in detail and illustrated at www.holcimfoundation.org/target. The following section of this book is a summary of the five criteria and how MAS Intimates Thurulie meets them.

Quantum change and transferability

Significant advancements in construction practice must be applied on a broad scale to support global sustainability. Practices and ideas that transfer best are those that are affordable, simple, and broadly applicable.

MAS Intimates Thurulie claims to be the world's first clothing factory powered solely by carbon-neutral sources.

The building is a visionary departure from the traditional factory. It meets very high standards for ethics and environmental stewardship in manufacturing.

As a model building under Marks & Spencer's eco-initiative Plan A, the project sets an example for the company, the apparel industry, and other industries.

Compared with the average factory, the design is outstanding in virtually every respect.

As the flagship factory of MAS Holdings, the building is a globally publicized icon that symbolizes the company's commitment to sustainable development.



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Ecological quality and energy conservation

Ecosystems worldwide are suffering under tremendous pressure. Buildings must conserve finite resources and minimize greenhouse gas emissions. Built environments must be healthful for humans, animals, and plants. Green buildings contribute to a healthy natural environment by reducing waste, controlling pollution, and treating land, air, and water as precious resources.

MAS Intimates Thurulie was designed in compliance with USGBC standards for green buildings and complies with LEED* Platinum standards. This certification attests outstanding overall environmental performance.

Energy required for operation is 25 percent lower than that of comparable factories. Only renewable and carbon-neutral energy sources are used.

The building is carefully situated on the intensively planted site to minimize its footprint and maximize open space.

Every drop of water on the site is carefully managed; consumption of potable water is half that of comparable factories.

To reduce the gray energy in the building, the main exterior walls are made of compressed stabilized earth block manufactured 40 kilometers from the site.



* LEED (Leadership in Energy and Environmental Design) is the Green Building Rating System™ of the U.S. Green Building Council. Platinum is the highest LEED rating. Buildings that have attained this rigorous level of certification are among the greenest in the world.



Ethical standards and social equity

As the global population expands, ethical imbalance becomes another threat to sustainability. In developing countries, the chief mandate of construction is to ensure basic needs such as shelter, water, schools, and access to goods, services, and medical care. In developed countries, the challenge is to achieve socially equitable stewardship of natural resources. All settlements and buildings should respond to emotional and psychological needs of people by providing stimulating environments, raising awareness of important values, inspiring the human spirit, and bonding society. Sustainable construction includes fair and respectful treatment of everyone involved during the design, construction, use, and recycling of buildings and cities.

Health and well-being of staff are central to the design of MAS Intimates Thurulie. The building offers a comfortable, healthful, and attractive indoor environment for all users.

As part of its service to employees, the plant transports employees to and from work, provides free lunches for staff, trains workers, and provides on-site conveniences such as medical care and banking.

The production floor is divided into separate areas where workers collaborate in teams, enhancing productivity and employee satisfaction.

The eco-factory is an ethical response to consumers who called for stronger environmental stewardship.

The beautiful and stimulating environment is uplifting; the factory is a place where people feel treated with respect and dignity.





MAS INTIMATES
THURULIE

Economic performance and compatibility

Buildings must be financially feasible to build, operate, maintain, and ultimately remove. They should support sustainable economic mechanisms, activities, and purposes. Construction projects can stimulate local economies, lead to broader economic integration, help establish long-term bases for livelihoods, and serve to distribute wealth.

MAS Intimates Thurulie is designed for lean manufacturing; the factory is profitable to operate, displaying energy efficiency, operational efficiency, and high productivity.

Because operation is very efficient, the payback period for the extra cost of making the building green is only five years.

The iconic building enhances the brand equity of the manufacturer, MAS Intimates; its group, MAS Holdings; and its retailer, Marks & Spencer.

The new factory helps revive a former industrial center, reestablishing a local economic base and providing long-term employment for 1,300 people.

As a motor of the new MAS Fabric Park, the plant is central to the further development of an efficient manufacturing hub.





Contextual and aesthetic impact

Sustainable architecture is durable and adaptable. It provides attractive, comfortable, and functional indoor environments. It enhances its surroundings, fitting functionally and aesthetically into its setting, providing culturally valuable indoor and outdoor spaces.

MAS Intimates Thurulie offers a pleasant and functional indoor environment that ideally supports lean manufacturing.

The building harmonizes with its site; indoor and outdoor spaces are integrated into a green park.

Built literally of local soil, furnished and finished with indigenous materials such as bamboo, and incorporating traditional Sri Lankan architectural elements such as courtyards, the building is of and for the locality and culture in which it exists.

To economically achieve a comfortable indoor environment, the design responds to its tropical climate with a full array of passive cooling measures and with an energy-efficient mechanical cooling system.

The building is a catalyst for the 68-hectare MAS Fabric Park, planned as a mixed-use rural settlement that offers a high-quality environment for working and living.







MAS Thurulie

By Daniel Wentz



MAS Fabric Park and MAS Intimates



Apparel production and export accounts for two-thirds of Sri Lanka's industrial product. The three-billion-dollar industry is the country's largest export earner, directly and indirectly supporting one million of the nation's twenty-one million inhabitants.



Thulhiriya Textile Mills was established in 1968 as a state institution in Thulhiriya, a rural community 65 kilometers northeast of Colombo. In the 1970s the 68-hectare park was the largest mill complex in Asia, the motor of the regional economy, and a driver of national industrial development. The complex declined after it was privatized in the 1980s. Further investments and improvements were made, but the complex ultimately failed. It was closed in 2003, which devastated the local economy. The state tried to revive the complex, but without success.



In 2006 the government of Sri Lanka invited MAS Holdings, the country's largest clothing manufacturer, to lease the complex and revitalize it as a privately managed industrial park for textile processing and export. Thus MAS Fabric Park was formed from the remnants of its forty-year-old forerunner. The new lingerie factory MAS Intimates Thurulie opened there in 2008, initially employing several hundred people, and returning economic prosperity to the district.

Costs in Sri Lanka are higher than those in most of Asia, so Sri Lankan companies pick niches to survive. MAS makes sophisticated, high-value garments such as lingerie for Victoria's Secret and other leading brands. MAS Intimates Thurulie manufactures lingerie exclusively for Britain's biggest clothier, Marks & Spencer, which operates around 900 stores worldwide, including more than 600 in the UK. Marks & Spencer conducted a customer survey in 2006 that showed that 78 percent of its customers






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-  Fair partner
-  Health

www.marksandspencer.com/PlanA

wanted to know what materials go into the products they buy, where and how the items are made, and what the associated environmental impact is. Answering to this customer response, Marks & Spencer devised Plan A – a USD 340 million, five-year, company-wide environmental and social sustainability program. Plan A comprises a hundred points to be achieved by 2012, one of which is establishing model green factories that supply goods to Marks & Spencer.

Marks & Spencer invited three Sri Lankan suppliers to build such model factories; MAS Intimates Thurulie was the first plant to be designed in line with this plan. MAS believes the building is the first purpose-built green clothing factory in the world. All items produced at the factory are sold wholesale to Marks & Spencer. The bulk is shipped from Colombo to England, and a fraction to Marks & Spencer franchise holders based in Dubai, Hong Kong, and India.

The building cost USD 2.66 million. Marks & Spencer financed USD 400,000 of the sum, paying for much of the green design and for the plant's photo-voltaic system, the largest in Sri Lanka. Although MAS invested a great amount in the factory, Marks & Spencer pays no premium for the products, and provides no guarantee to purchase the merchandise produced.



We put all our energy into
designing a plant that will
save energy.

By using energy efficient lighting,
equipment and ventilation within
our plant we consume 40% less
energy compared to a similar size
plant.



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Plan A.



Climate Change



MAS INTERNATIONAL
THURSDAY

Site description



MAS Fabric Park is located in Thulhiriya, five kilometers from a hub where two important highways intersect. The park possesses well-developed infrastructure with roads, all utilities, and a water-treatment plant. The land is zoned into areas for industrial, warehousing, residential, commercial, institutional, and religious uses, and it includes small green zones. The residential zone is planned for 200 people; 80 people live there, 18 of whom work at MAS Intimates Thurulie.

MAS considered several sites in the industrial park for its new factory. Instead of reusing one of the vacant buildings in the park, the largest of which measures 500,000 square meters, the company built a new structure on an undeveloped site at the northern tip of the park. Deciding whether to build on a greenfield site or reuse buildings or building sites is a central issue in sustainable construction. Greenfield construction



- Site plan
- 1 Main entrance
 - 2 Workers' entrance
 - 3 Visitors' entrance
 - A Entrance house
 - B Lockers
 - C South wing
 - D Main hall
 - E North wing
 - F Shrine
 - G Administrative wing

requires compelling justification because each project of this type is another step in the incessant march to cover the earth with buildings and paving.

The chosen site had formerly served as a deer park and as a recreational site. It measures 3.32 hectares and is roughly trapezoidal, bordering Kurunegala Road to the east, the Ma Oya River bank reservation to the west, a DogiEFA factory to the south, and an electrical substation to the north. The general solar orientation is toward the northwest. The rolling terrain tumbles six meters from the highest point in the south corner to the lowest point in the west. Steep slopes are located only along the southern boundary. The soil is laterite with high clay content.

The climate is typical of the lowland wet zone of southwest Sri Lanka. Diurnal temperature fluctuation is greater than annual or seasonal fluctuation. Average daily temperatures vary from 23° to 30° Celsius. High temperatures exceeding 32°C occur about 65 days a year. The region has more than 100 rain days a year, with approximately 2,400 millimeters per year of rainfall. Humidity averages 74 percent, but can easily approach 90 percent in early morning and late evening during most of the year.



On the eastern half of the site grew tall grass, shrubs, and trees. A man-made pond, measuring about 6,900 square meters, has long occupied much of the western half of the site, which is densely covered with mature trees and thick shrubs (see back cover). This productive and sensitive biome is unfortunately zoned for industrial development. MAS wisely avoided building on this riparian area; in fact, the building effectively blocks development of it.



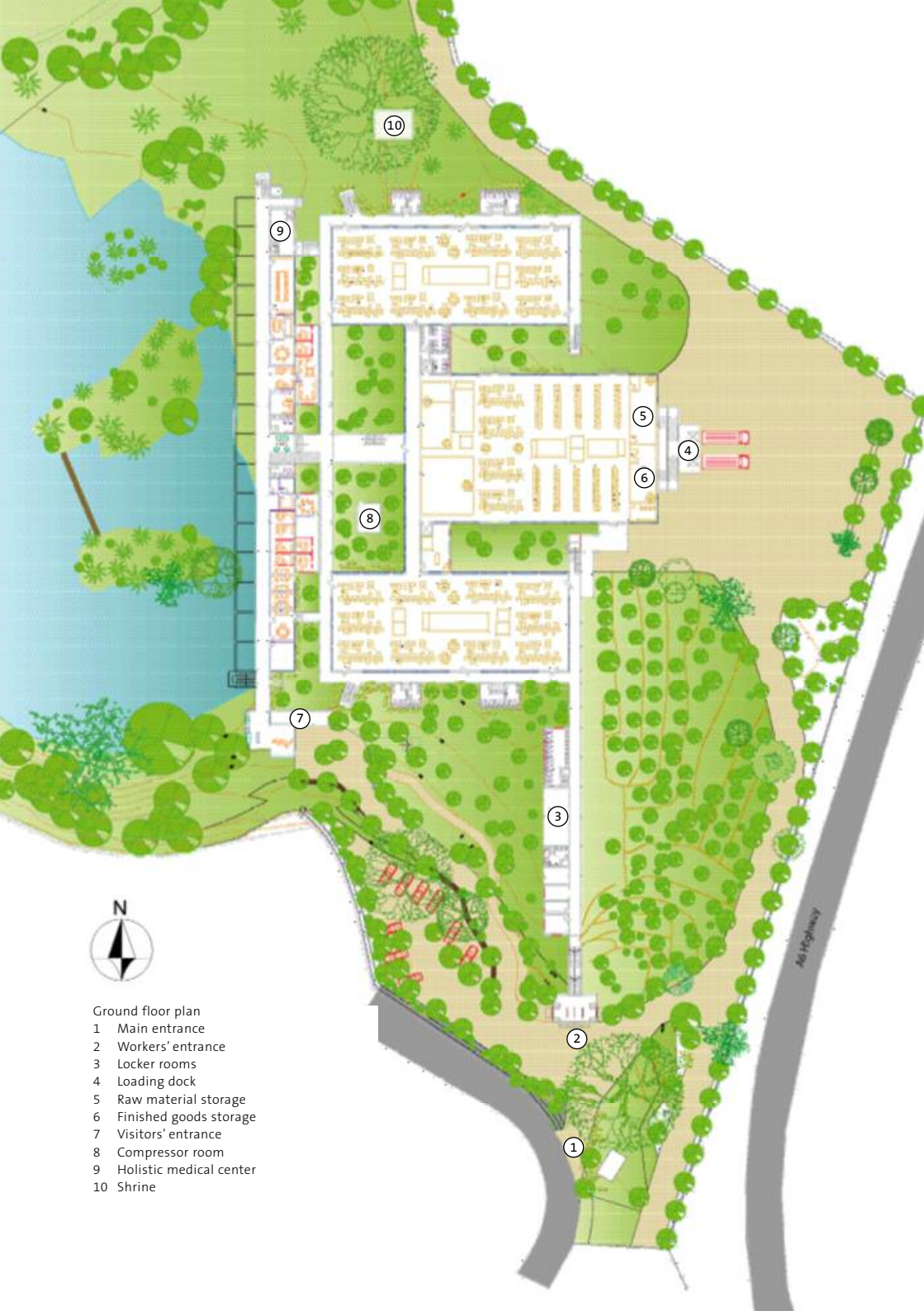
Site design



The thrust of the site design is to efficiently accommodate the factory and to maximize open space. This was achieved by planning a two-story building with a footprint of only 6,780 square meters, or roughly fifteen percent of the site. The remaining open space was either left undisturbed or planted for erosion control. The pond and the dense woods on the western part of the site were retained. Most large trees on the site were preserved. The building is located near the center of the site, situated in response to the terrain, climate, soil, and hydrology. Natural topography and drainage patterns were preserved as much as possible by situating the building along the contour lines and raising Building G (see page 27) on stilts.

The entrance to the site is at the southern tip. Pedestrian and vehicular circulation are segregated at the entrance and routed efficiently. The main road for trucks on the site follows the eastern boundary, leading directly to the loading docks. The employee entrance is just north of the main gate, and includes locker rooms and parking for 25 bicycles. Farther to the northwest is the visitor entrance. Immediately to the west of the entrance are ten parking spaces for cars of visitors and staff. Most of the 800 staff who work at the plant today commute by bus. It can be noted that if all staff were to commute by car, in the U.S. fashion, the site would be a parking lot. All roads, walks, and terraces on the site are paved with cement-stabilized earth instead of sealed pavement. The porous surface reduces runoff and helps recharge the groundwater. Paving covers about ten percent of the site.

About 400 trees were planted, doubling the number on the site. Essentially all areas not occupied by the building, pond, or pathways are planted with trees, most of them in the courtyards and in the green belt to the east of the building. The vegetation helps keep the factory cool. Shading of the building and grounds will keep the building an estimated 1 to 2°C cooler when the



Ground floor plan

- 1 Main entrance
- 2 Workers' entrance
- 3 Locker rooms
- 4 Loading dock
- 5 Raw material storage
- 6 Finished goods storage
- 7 Visitors' entrance
- 8 Compressor room
- 9 Holistic medical center
- 10 Shrine



trees mature and the green canopy spreads. Requirements for watering and maintenance are reduced because endemic and adapted species were selected. Rare, endangered, and medicinal species were planted as well.



Thulhiriya is in the intermediate climate zone of Sri Lanka. The site can host plants from the country's wet zone and dry zone. Species from both zones are present. For example, at the top of the cascade, dry-zone plants thrive in the strong sun. At the base, where water accumulates, wet-zone plants thrive in the moisture. The green roofs of the building are planted with a local grass variety and some medicinal herbs. This flora requires little maintenance. No drop of water that enters the site is lost without providing some benefit. Green areas are designed to absorb up to 25 millimeters of rain before runoff begins. Erosion is controlled by porous surfaces, dense planting, and, where necessary on steep slopes, stabilized soil. Runoff is channeled to the retention pond, which serves as the primary irrigation source for plants on the site.



The pond was dredged and enlarged to increase its irrigation capacity. Native fish species and indigenous water plants were introduced. MAS reports that the number and variety of species on the site has expanded significantly, especially reptiles and birds, including waterfowl. The facility is used during daylight hours only. At night the site is left to nature, and emissions of light and noise are kept low.

The image of MAS Intimates Thurulie is that of a factory in a garden paradise, because three quarters of the verdant site remains unbuilt. Except for the untouched forest, the greenery and water are handled primarily as scenery or functional amenities and secondarily as natural habitat. By placing greater emphasis on site ecology, the environmental impact of this model green factory could be further reduced. Our concept of landscaping must expand





from “design” – using natural features for functions such as beautification, shading, irrigation, or soil stabilization – to include habitat – maintaining natural spaces as pieces of a larger fabric essential to wildlife survival.

MAS Intimates Thurulie could fully apply this concept by embracing the tenet *protect, connect, and recreate*. The pond is designed primarily for retention of irrigation water, decorated with islands and a footbridge, and designed for visitors to walk around it. The trails could be closed, and the bridge removed to prevent human intrusion into the biotope. Much of the bank is unnaturally steep and devoid of typical flora; nature is a perfect guide for appropriate slopes and variegated planting. The fence around the site prevents many animals, particularly mammals, from entering the site, foraging, or reaching the pond; it could be opened to allow passage and connect isolated habitats. The field to the east of the building is a monoculture turf dotted with trees – a 3,000-square-meter lawn; it could be developed into valuable habitat if it were designed and planted with nature as the model by adding a diversity of tall grasses, large plants, and shrubs, all allowed to undergo seasonal cycles of blooming, going to seed, and withering, with minimal intervention, otherwise known as “grounds maintenance.”

Such improvements would be relatively easy to make at MAS Intimates Thurulie. They would not only enhance the building's status as an environmentally attuned factory, they could serve as an instructive example of vital but often overlooked ecological principles that apply in every backyard. Exemplary ecological site design could serve to sensitize and educate plant employees, visitors, and a potentially broader audience about design with nature. Such a plan must be part of the mission of a model green factory, especially a greenfield project that claims for itself such a large piece of land, with a floor-area ratio of 1:4.

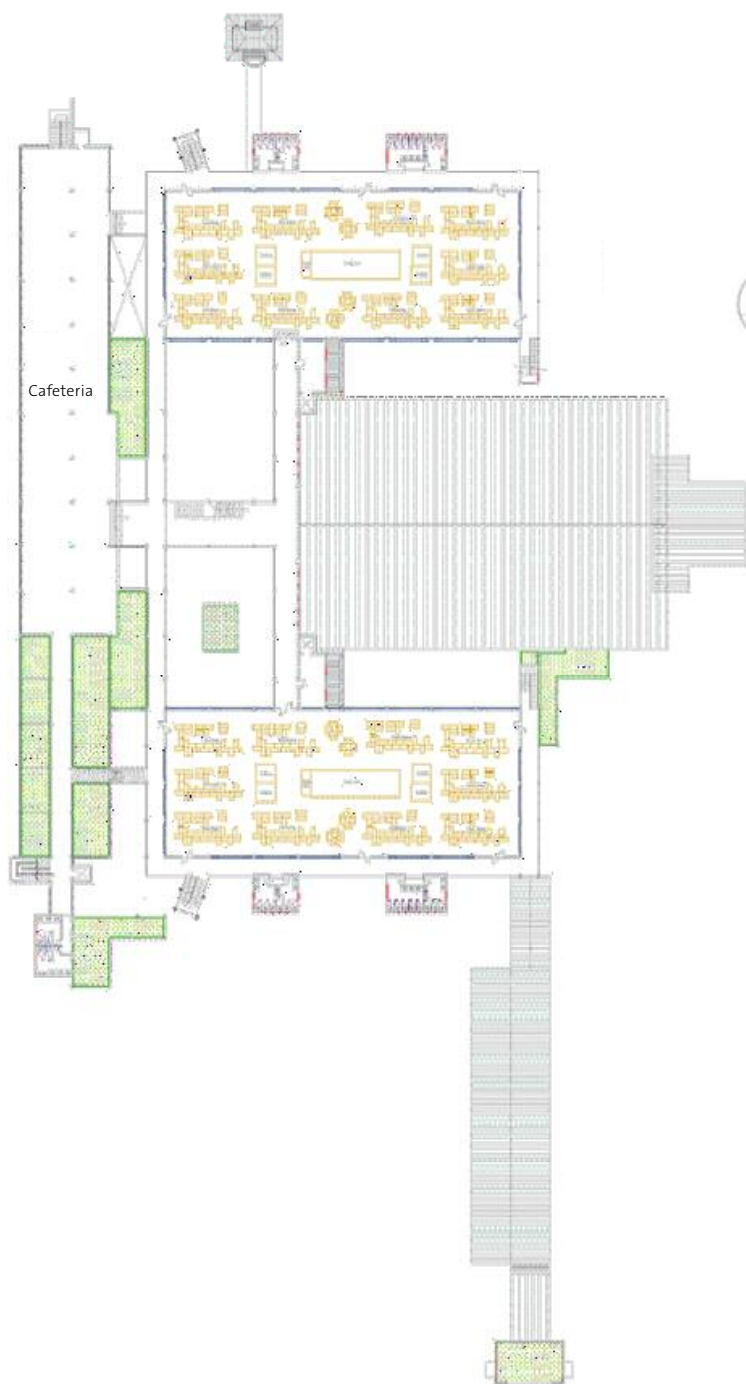


Building program

MAS Intimates Thurulie, conceived as a 10,000-square-meter building for 1,300 people, is the first MAS plant designed fully in line with the MAS Operating System, the company's lean-production standard. In contrast to the industry norm, in which the typical factory is a single large hall, the lean-production standard requires smaller production areas, each containing a complete value stream, from cutting fabric to packaging finished garments.

The production floors are free from columns and other obstacles so that each production team can arrange its machinery to best suit the garments being made. The arrangement of electrical receptacles and lighting fixtures provides the same flexibility. In the first year of operation the floor layout was changed several times to accommodate efficient production of new styles of articles.





Upper floor plan

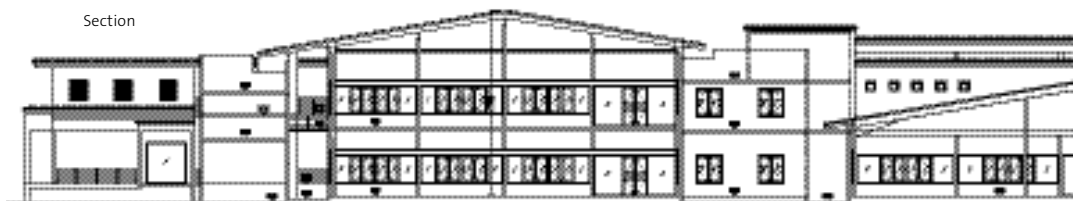




In addition to the comfortable atmosphere in the production halls, the workers enjoy a range of service spaces and amenities. Each hall has its own service spaces including mechanics' room, meeting areas, and toilets. The cafeteria, offices, board rooms, reception foyer, and main corridors enjoy views of the pond. The shrine, to the north, stands beneath a mature Bo tree, or sacred fig (*ficus religiosa*). This tree has special significance to Buddhists, the predominant local religious group. Company standards require adequate circulation paths, barrier-free accessibility throughout the building, and compliance with all relevant fire and safety requirements. Showers, toilets, and lockers for employees are provided at the main entrance area. The plant infirmary provides holistic medical services.

The administrative wing houses chiefly offices and meeting rooms. The collaborative style of working at the plant calls for places for impromptu meetings without the trappings of isolated meeting rooms. The company calls these quiet, open work areas relax stations.

Section





Sustainable approach



Both MAS Holdings and Marks & Spencer intended the factory to be an iconic model for green manufacturing, to set new standards for design, construction, and operation. Incorporating advanced technology in most areas, the building does this in several ways.



To realize a sustainable design, the design team applied a three-point philosophy of respect for the site, respect for users, and respect for eco-systems. These three aims, complementing the functional and commercial requirements for the project, served as selection criteria for all materials and systems used in the building. The design is inspired by traditional Sri Lankan architecture, built partially on stilts, with courtyards, amid lush greenery.



The building is energy efficient and the indoor climate is comfortable, a challenging combination in the tropics. It is powered by carbon-neutral sources, and it uses half the water of comparable factories, even though the grounds are a veritable garden. The facility incorporates an anaerobic digestion system for sewage treatment. These are all suggestions of Plan A.



Passive cooling

The building is designed for efficient production, a comfortable atmosphere, and low energy consumption. Meeting these three criteria in the tropics means mastering above all one thing – cooling. Cooling is achieved at the plant primarily by passive design and secondarily by active systems. Passive design measures include the orientation and massing of building volumes, controlled fenestration and ventilation, shading of the building and its surroundings, and thermal mass and solar reflectivity of the facades and roofs.



East Elevation



The high angle of the sun during most of the year makes the south facade the easiest to shade and the east and west facades the most difficult. Thus, the main building volumes, the production spaces, are aligned on an east-west axis, the north and south facades being the largest. This orientation makes it easier to block direct solar radiation.



The massing of the building volumes and the positioning and sizing of windows permit daylight to enter as natural illumination without causing substantial heat gain. Horizontal shading intercepts the northern sun at midyear and the southern sun later in the year.



Thermal roof load, the largest contributor to heat gain and indoor discomfort in the tropics, is controlled by a combination of green roofs, photovoltaic roofs, and cool roofs. Green roofs cover 1,757 square meters of the building. They are installed on concrete decks over shortspan spaces in the administrative wing. Covered with turf and plants, the high thermal mass of this roof absorbs heat without transmitting it into the building. The cool roof is a lightweight metal roof assembly over the longspan production halls. The white metal, with a solar reflectivity index of 79, reflects nearly eighty percent of the solar energy that reaches the roof.





The photovoltaic roof covers 200 square meters of the building with solar panels. This system not only prevents thermal gain, it transforms the solar energy into electricity.



Another passive means of keeping the building cool is to cool the micro-climate, or reduce the ambient heat around the building. The heat-island effect around the building is controlled by shading, by covering parking areas, by using lighter, reflective paving around the building instead of dark, heat-absorbent paving, and by shading the courtyards between the building volumes. The combination of the many passive cooling measures reduces the thermal load to a level that can be handled by environmentally efficient cooling systems instead of power-hungry conventional systems.



Production model



Once the final wing is complete, the facility will accommodate 1,300 occupants, including nearly 1,100 machine operators. With a worker-centered design, industrial processes follow the high-productivity MAS lean-manufacturing standard. The production floor is separated into five halls on two floors. This makes climate control more efficient and it allows housing complete value chains within each hall. At the time of writing, all wings of the facility were built except the north wing, the construction of which is scheduled to begin in 2009.

Just-in-time manufacturing processes dramatically reduce storage space required for raw materials and finished goods at the plant, leaving more area for production. The production spaces are designed for inventory-free operation, meaning that the day's raw materials are delivered in the morning and the finished and packed garments leave the floor in the evening. The internal layout is designed to minimize transportation. Everything machine operators need is within arm's reach, and dedicated spaces are provided for systematic problem-solving.

The layout provides visual connection between offices and production floors. The plant is wireless-network enabled, and nearly all computer users have laptops and mobile phones linked to the company phone system, giving staff the mobility to work anywhere in the facility. Managers are encouraged to work with their teams in small groups on the production floor. Meeting areas and lounges are interspersed throughout the building, encouraging impromptu exchanges.



Employee well-being



In the interest of worker well-being, the design team paid special attention to the work areas, particularly regarding an attractive environment, pleasant outdoor views, thermal comfort, fresh air, and illumination, including natural lighting and task lighting. Large windows are a key part of the design, bringing the green outdoors into all working spaces. “We feel like we’re working in a natural environment. There are trees around and good ventilation though there is no air conditioning,” tells machine operator Harshini Maheshika.



Also in the interest of worker convenience, MAS operates chartered buses between the plant and nearby villages. Most employees commute by bus. Mass transit options will increase as more factories open in the park. The plant also provides free meals, medical care, and on-site banking. MAS developed “Women Go Beyond,” a program to educate and empower women, who comprise 85 percent of the plant’s workforce. MAS has strong community relationships and commitments to society. Mahesh Amalean, Chairman of MAS Holdings, says: “We believe strongly that if the people we work with have their basic needs taken care of, they are freer to concentrate on the work at hand and bring out their best.” The facility is OHSAS 18001 certified. OHSAS 18001 is an internationally recognized standard for occupational health and safety management.



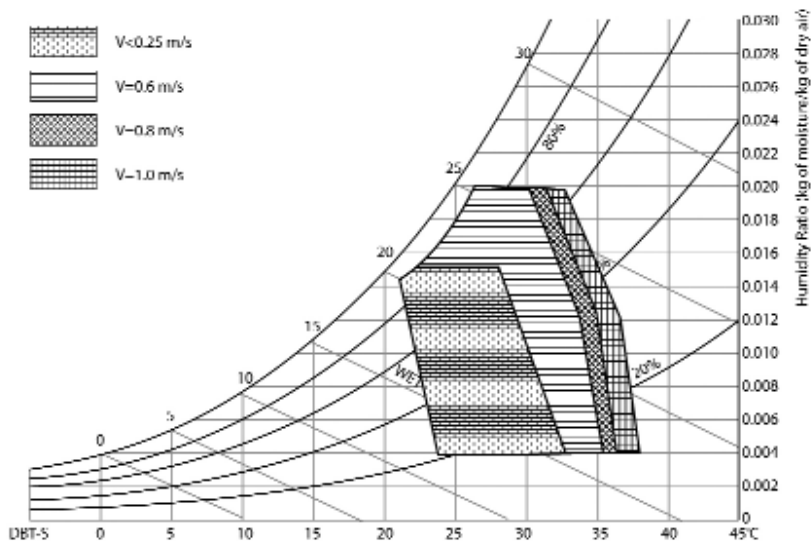
Indoor thermal comfort

Production spaces and offices are ventilated and cooled by evaporative cooling units. These units draw in fresh air, filter it, and add moisture to lower the dry-bulb temperature. The air is distributed through a balanced system of ducts and fed into the spaces, which remain under positive static pressure. Indoor air is not recirculated, but extracted by suitably sized exhaust fans to ensure effective moisture and heat removal. The air-exchange rate is about 40 air changes per hour. Indoor air movement is perceptible, about 0.8 meters per second at the minimum. ANSI/ASHRAE Standard 55-2004 allows the thermal comfort zone to be extended upward by about 2.7°C when indoor air velocity is 0.7 meters per second. The psychrometric chart at right shows the extended comfort zone at higher indoor air speeds considering ASHRAE 55-2004 and research conducted in tropical climates.

Year round, the indoor dry-bulb temperature is up to 3°C cooler than the outdoors, and the indoor relative humidity about ten percent higher than the outdoors. Humidistats in each cooling unit keep the indoor relative humidity

At lunch, employees of MAS Intimates Thurulie enjoy the breeze and beautiful view from the cafeteria.





Psychrometric chart from the ASHRAE Standard Handbook showing extended comfort zones. The cooling system at MAS Intimates Thurlie is designed to make use of these zones and make use of Section 5.2.3 of ANSI/ASHRAE Standard 55-2004.

at or below 80 percent. Staff wear short-sleeve shirts, many workers go barefoot. The combination of dressing cool, activity at low metabolic rates, and air movement makes the plant a comfortable working environment.

The maximum observed temperature on the ground floor of Building C is 29.5°C, which is acceptable because the indoor air velocity of 0.8 meters per second keeps the environment within the extended comfort zone.

Each evaporative cooler cools the work areas of one to two work teams. The teams are free to adjust the airflow and indoor velocity as they choose by selecting one of five fan-speed settings on the cooler unit. Air velocity is maintained by the balanced duct system with preset diffuser arrangement.

Offices have adjustable diffusers. Larger offices have multiple diffusers, so everyone can adjust airflow at their desk as they wish.

The cafeteria is naturally ventilated, taking advantage of its situation on the upper floor overlooking the pond. The green roof and shade of trees helps keep the space cool. A steady breeze usually provides adequate ventilation, eliminating the need for mechanical ventilation.



Construction materials



To reduce the gray energy or embodied energy (energy expended to process and transport materials) in the building, the main walls are made of compressed stabilized-earth block manufactured forty kilometers from the site. The machine-molded blocks are made of local soil, sand, and locally manufactured cement. The large size of the blocks minimizes mortar joints. The walls require no plaster finish; they are simply sealed with varnish on the interior and exterior.



In contrast to the low-energy block, most other main materials in the building are conventional materials that embody high amounts of gray energy. Roofing is zinc-aluminum imported from Australia. Windows use imported plate glass and aluminum frames. The building is framed in locally made concrete and steel manufactured from imported billets. Gray energy could have been reduced by reducing structural spans, dividing glazing units into smaller sizes, and using wooden windows instead of aluminum. Floor finishes include polished concrete tile, rendered and cut concrete, tile, and wood.







Bamboo is used for window blinds and various forms of sunscreen. Non-hazardous finishes and materials are used throughout the building, ensuring good indoor air quality, which is enhanced by high air-exchange rates. Partitions are gypsum board and tabletops MDF. The design team says that no viable greener alternatives are available in Sri Lanka.



Construction was carefully managed to minimize environmental impact. Topsoil was segregated during excavation and reused later. Stabilizing plants, silt traps, and stormwater-collection ponds were used to prevent soil erosion during construction. Much of the construction debris was used in the sub-base for paving on the site, and special mechanisms were introduced to recycle construction waste, which reduced the amount of waste that went into landfills.





Economic performance



The factory cost USD 2.66 million to build. The unit cost is 25 percent higher than that of conventional factories in Sri Lanka. MAS expects the higher construction cost to be amortized within the first five years because of energy-efficient operation of the building and the high operational efficiency achieved through MOS, the lean-manufacturing standard of MAS. The factory purchases its green power at a premium, an added cost it can afford because power consumption is low.



The additional cost of the green and ethical building creates intangible but substantial value in the form of goodwill. The building enhances the image of both MAS Holdings and Marks & Spencer, reinforcing the reputations of both as responsible and ethical companies.

The plant will provide 1,300 permanent fulltime jobs, revitalizing the local rural economy. The plant's only customer is Marks & Spencer. MAS plans to invest USD one million in the park and achieve many forms of synergy among the various plants.

Taking a broader view, one must question the sustainability of business models in which the entire production of factories is shipped thousands of kilometers – particularly when staple industries such as textile weaving and sewing are virtually disappearing from developed Western countries.



Energy efficiency



MAS Intimates Thurulie was designed for low energy consumption by reducing power demand and by using efficient equipment. Electricity is virtually the sole form of energy used by clothing factories in Sri Lanka, required chiefly for production machinery, lighting, and air conditioning. Air conditioning alone accounts for about half the consumption in typical plants with conventional vapor-compression equipment. Using passive design to reduce heat loads and efficient evaporative cooling equipment, an indoor temperature of 27° to 29.5°C (compared with 25° to 26°C in an average factory) is maintained, while consuming only 25 percent of the cooling energy of an average factory.

Energy consumption for lighting was reduced by maximizing daylighting and by using well-designed systems with efficient lamps. Offices, cafeteria, lounge, reception area, meeting rooms, and boardrooms are normally illuminated by daylight only. The glare-free illumination is usually adequate even on rainy days. Daylight is adequate roughly from 6 a.m. to 6 p.m., which easily covers the normal operating hours of the plant. An added benefit of foregoing artificial lighting is reduced heat gain within the building.

In conventional factories the whole production floor is floodlit at a uniform high intensity. At Thurulie, aisles are illuminated with natural and ambient light, and work areas are illuminated with task lighting – high-efficiency T5 tubes and LED lamps mounted on the sewing machines – focusing the correct amount of light at needlepoint. This system requires about half the normal number of light fixtures. Every light fixture can be easily repositioned and switched on and off individually as required. Sewing machines with direct-drive servo motors were chosen for energy efficiency.



	MAS Intimates Thurulie	Reference Plant 1	Reference Plant 2	Annual energy consumption for MAS Intimates Thurulie and two other MAS plants (figures for produc- tion halls only)
Indoor cooling [USD/m ²]	0.40	1.95	1.34	
Lighting [W/m ²]	11	30	28	
Light fixtures/m ²	0.388	0.775	0.560	

Water management



Every drop of water that enters the site is carefully managed. Consumption of potable water is about half that of comparable plants.



Rainwater that falls on the cool roofs is collected and used for flushing toilets. The storage tanks and toilets are gravity fed, eliminating the need for pumps. When the tanks run dry during a drought, water is sourced from the park's system. When the tanks become full after prolonged rain, the overflow is piped underground into the pond. Rain patterns are such that rainwater covers ninety percent of the flushing needs. Rainwater that falls on the green roofs is collected, channeled through a gravel-and-sand filter, and discharged into the pond, which naturally recharges the groundwater. Overflow from the pond feeds into the Ma Oya River.



Wastewater from all plumbing fixtures is treated on site in an anaerobic plant. The system uses very little power – relying primarily on gravity and using pumps only for the last stage. Water discharged from the treatment plant passes through an absorption-and-filtration bed, and the purified water is then fed into the retention pond.

The factory uses potable water only for cooking, washing, drinking (after filtration), for the evaporative cooling system, and as a backup for flushing toilets. Dual-flush toilets and low-flow plumbing fixtures minimize water consumption. The water comes from the Ma Oya River, which borders the park. It is purified and distributed by MAS Fabric Park. The plant is not connected to a municipal sewer or water distribution system. No water is used in production.



Clean energy

The plant's two primary energy sources, photovoltaic and hydroelectric power, are renewable and carbon neutral. The rooftop photovoltaic system with output of 25.6 kilowatts covers ten percent of the plant's power needs. Thurulie boasts the first use of net metering in Sri Lanka.

Net metering is an arrangement between the power company and consumer whereby the consumer is credited for the electricity it generates and feeds into the grid. At Thurulie this happens on weekends and holidays.



A small hydroelectric power plant connected to the public grid provides the other ninety percent of the factory's power. The green-power-supply agreement for Thurulie is the first such agreement in Sri Lanka.

Three electric bikes are used at the plant. The plant is equipped with a vacuum-tube system for solar water heating. Water is preheated in the tubes and then heated in conventional boilers. The water is used for brewing tea for all employees twice a day. Methane gas from the sewage-treatment plant is collected for firing stoves and ovens in the kitchen.



Green manufacturing



MAS Intimates Thurulie is a heartening picture of what green manufacturing can be – an energy-efficient plant using carbon-neutral power from renewable sources, a non-polluting, resource-conserving operation in an environmentally friendly setting. The plant strives toward zero waste in landfills. Empty thread cones are recycled, as are paper, plastics, glass, and metal. MAS is collaborating with Marks & Spencer to develop a fabric-defibering system for fabric waste. Fabric scraps currently go to local craftspeople. The company seeks to reduce transport-related CO₂ emissions by offering financial incentives for employees who commute by bicycle or bus.

Manufacturing at MAS Intimates Thurulie is a link in a supply chain that begins with base materials sourced in Asia and ends with finished products sold primarily in the UK. The bulk of production is trucked to Colombo, shipped 6,700 nautical miles to the UK, and distributed by truck to Marks & Spencer stores. The fossil-fuel consumption and CO₂ emissions of distribution stand in jarring contrast to the carbon-neutral clean-energy factory. In fact, it seems incredible that the green manufacturing and energy-intensive distribution are links of the same supply chain.

But shipping is commonplace these days, not only in the apparel industry. Ninety percent of the world's goods are carried by sea, and volumes are increasing. Shipping now accounts for five percent of global CO₂ emissions. Greening of global supply chains is such a complex challenge that companies alone can hardly master the task. Greening of individual links in supply chains is however a step in the right direction, and MAS Intimates Thurulie is an outstanding example of a bright green manufacturing link.





“Creating awareness and understanding for sustainability”

Interview with Vidhura Ralapanawe, Manager Sustainability and Communications at MAS Intimates and team leader for the MAS Intimates Thurulie building project

Has this green building changed people's attitude toward sustainability?

Vidhura Ralapanawe: A building should always invite a person to engage, to create curiosity. At Thurulie we wanted to create a curiosity and an interest to look into the concept of sustainability.

This is a big philosophical challenge, because while many will broadly articulate what it is, there is very little consensus on how radical the shift has to be, beyond business as usual. If we need broader engagement and enhancement of discourse, a mere green building would not have sufficed.

During the design phase, we made a conscious choice to optimize the building-human ecosystem rather than just the building. The building invites the active participation of its occupants for optimal functioning. There are required behavioral changes – more climate-appropriate clothing, being a conscious consumer of energy, i.e. switching off lights in lavatories and workspaces when not needed.

All of this is achieved with creating awareness and understanding. All occupants of the building get detailed training that explains the whys and hows of the building. If we are to move into a sustainable society, we need radical behavioral change. We could have designed a motion-sensitive lighting system that automatically switches off when no one is around. But if one gets used to switching off an unnecessary light at work, he or she will do the same thing at home. And we know this is actually happening. This is a learning center. In the first six months of operations, we have hosted more than 1,000 people coming to see the factory – people from

“We made a conscious choice to optimize the building-human ecosystem rather than just the building.”

the apparel industry, construction industry, industrialists, academia, competitors, and students. We discuss climate change and its local impacts. We framed our approach in broader environmental principles. We have made it iconic and accessible, taking time to explain the principles behind what we do, and a lot of the visitors take something back.

Thurulie has inspired many suppliers to Marks & Spencer on their own journeys toward creating sustainable buildings. I think we have created a transformational building.

MAS Intimates Thurulie is designed to meet LEED criteria for green buildings. How did you incorporate this criteria into the design process for this building? Do you think there is a danger of using the criteria as a checklist to collect certification points, but missing the unique opportunities that each project presents?

There is the danger of LEED becoming a straightjacket rather than an enabler, and the distinction lies in the hands of the designers. LEED came into the picture later in the design process – once the concept, form, and structures were well defined. So LEED was never the driver of the design. I always consider Thurulie to be first a green building, and second a LEED building. For us, LEED was never the ultimate test of sustainability.

LEED of course is a consensus standard, and that has its inherent challenges. But sustainability demands that one break free from the orthodoxy, and designers need to be daring enough to look beyond LEED. We have applied for LEED Platinum certification, and we expect to receive it very soon. When we do, this will be the first LEED Platinum certification for a newly constructed building in Sri Lanka.

The building footprint could have been further reduced by adding a third floor. Was this considered? The production halls are column free for production flexibility. A central row or two or three columns could have halved the span, greatly reducing the steel framing. Why wasn't this done?

Factories in Sri Lanka are built as column-free single story buildings. Two-story is itself a departure from the traditional style. Multiple stories do pose challenges – in terms of regular goods and people movement, as well as fire safety. Installing columns would have reduced steel framing, but our lean processes demand column-free spaces. It gives additional flexibility in changing the layouts of each production cell as well as the overall layout within the production hall as well as enabling line-of-sight visibility of the complete production floor from any one location.

While we could have worked with the current team to come up with a suitable layout, that is merely a transient solution. The facility needs to be able to support different product and or manufacturing processes. Shifting away from the conventional column-free factory model could have hindered the longer term usability of the facility.

The design of Thurulie relies on trees for functionality and aesthetics. What prompted this choice?

It's partly influenced by the location. Thulhiriya is an area with lush verdancy, and the same can be said of the homes of most employees working in the factory. So there is a natural affinity to this type of a setting compared to a sterile factory type of setting. Trees also bring in a natural harmony to the surroundings, in addition to the cooling properties and carbon sequestration it brings.

On top of that, there is the aesthetic impact. The fluidity of the form, and how it interplays with the strong lines of the building, and the utter calmness that the surrounding brings into the busy working environment... it is exactly what we wanted to achieve. And in a few years time, when the newly planted trees really spread out and thrive, this facility would be phenomenal to behold.

MAS as an organization also has an affiliation to an aesthetic heavily reliant on trees and landscape – an initiative personally driven by MAS Intimates CEO Dian Gomes.

From conception to opening of the factory, the project took only thirteen months – a remarkable achievement. How was this possible?

Time was perhaps the biggest challenge we had. From the beginning we understood that we had to create new rules of engagement between the three entities – design team, contractors, and the company – if we were to deliver the project on time. Success of the project depended on how well the relationship worked.

We were fortunate to tap into multiple synergies across the whole process. There was a sense of experimentation and breaking boundaries that permeated across all parties all the way to subcontractors. There was proactive engagement and a deep amount of trust. This enabled us to tap into creativity at a grassroots level all the way to the masons. Thus at the end the facility became better than we envisaged, staying true to the original principles laid out thirteen months ago.

Still we did not leave anything to chance. The thermal control systems were simulated and then deployed in trial spaces to tweak the system. The materials were tested for structural properties. The rapid schedule was not a shortcut.

We needed an exceptional team, who were brilliant in their own fields, yet open enough to create synergies and build on each other. We were able to create an idea of being explorers together, which was brilliantly utilized by Ushaan Abeywickrama, General Manager of MAS Intimates Thurulie, to ensure that the execution was exceptional and two weeks before schedule.





Technical data

Site	Location: Thulhiriya, Sri Lanka
	Climate: tropical, humid
	Terrain: rolling, moderately sloped
	Area: 3.32 hectares
	Setting: rural industrial park
	Parking: 10 spaces for vehicles and 25 for bicycles
Building	Construction period: September 2007 to April 2008
	Building type: clothing factory
	Building volume: 48,486 m ³
	Maximum number of occupants: 1,300
	Gross usable floor area: 7,854 m ² (final floor area: 10,000 m ²)
	Number of finished floors: 2
	Number of basements: 0
	Construction: concrete and steel framing; compressed stabilized-earth block (CSEB) exterior walls; zinc-aluminum roofing and green roofs
	Construction cost: USD 2.66 million (338.50 USD/m ²)
	Construction cost of typical factories in Sri Lanka: 308 USD/m ²
	Annual operating cost: 0.4 USD/m ²
	Annual operating cost of comparable factories in Sri Lanka: 1.61 USD/m ²



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“Making an industrial building fundamentally sustainable”

Interview with Dr. Hansjürg Leibundgut, Professor of Building Services at the Institute of Building Technology, Swiss Federal Institute of Technology (ETH Zurich). He is also a partner of Amstein + Walthert Engineering and Consulting, Zurich, and a member of the Technical Competence Center (TCC) of the Holcim Foundation.

Professor Leibundgut, are the sustainability challenges of industrial buildings different than those of residential or office buildings?

Hansjürg Leibundgut: Industrial buildings normally have a shorter service life; generally, they will be converted or demolished sooner. The consequence of this is greater consumption of materials – and that lower-quality materials tend to be used. In industry, buildings are often considered a necessary evil that serve primarily to protect valuable machinery. Everything is very pragmatic. This also affects the quality of the workplaces; for instance, one pays little attention to acoustics, good lighting is provided only where it is really necessary, and so on.

Does this mean industrial buildings have a lot of catching up to do in terms of sustainability?

It depends on what you mean by sustainability. In some cases the construction of a high-quality industrial building would be a disservice to the environment, because perhaps more valuable material would be used, although the building might be torn down after a few years. The fundamental principle is always to consume as little material as possible. But even this criterion must be assessed case by case. At the factory in Thulhiriya one could have saved steel framing material by installing midspan columns – but then the halls would not have been as useful as they are now.

How can one make an industrial building fundamentally sustainable?

I define sustainability for all buildings, not only industrial buildings, as avoiding non-sustainability. One refrains from everything that is not sustainable.

Does this factory meet this definition?

In my opinion, clearly – although there are of course always things that one could have done even better. The quality of this building is much high-

er than that of all other factories in the region. This applies to many aspects, including social, economic, and aesthetic. Less cement per person was used than the norm, less steel, less space. Plastics were avoided almost completely. The building is very cleverly designed.

Does the situation in Sri Lanka promote such sustainable buildings?

On one hand, environmental awareness in Sri Lanka is still weak. I had intensive discussions with the project leader; everyone involved in this project is highly committed and interested – but that is still an exception in Sri Lanka. On the other hand, Sri Lanka offers a good legal and climatic environment for sustainable construction. In other world regions builders must observe completely other standards; for example they are forced to use much more material. And the climatic conditions are of course quite favorable in the tropics – although in this case this also presented special challenges.

In what way?

Such humid regions are not especially suitable for textile production. At the moment, the spaces in the factory are cooled by spraying atomized water into the air passing through the cooler units. If temperatures rise in the next few years due to climate change, this system will no longer suffice. Because if the air were even moister,

“I define sustainability for all buildings, not only industrial buildings, as avoiding non-sustainability. One refrains from everything that is not sustainable.”

one would reach the limit of tolerable humidity levels; then nothing dries any longer and no textiles can be produced. One would then require another mechanical form of dehumidification.

Does that mean the building will be less sustainable in the future because electric dehumidifiers will be required?

Not necessarily. One could install more photovoltaic panels on the roof of the factory and use solar energy to power the dehumidification. We must not always act as if technology were a tool of the devil. Today passive buildings are considered the ultimate solution – but I consider the widespread preference for passive methods a mistake. In recent years we have seen technical developments that really get us further – for example, wind energy. Now we must use this enormous advancement sensibly.

How does this factory measure up regarding social sustainability?

I have been in many places during my lifetime, but hardly any building has impressed me like this one. The workers – and I do not mean representatives of the management – were raving to me about the social benefits, such as the medical checkups. One senses the well-being of the people. And that is also an advantage for the company – employee absenteeism is much lower than before.

The factory is situated in an area where nature flourishes with particular vitality. In such a setting, may one treat the environment with a bit less regard than elsewhere?

Definitely. Disruptions that cannot be eliminated within a useful period of time are non-sustainable. Other standards apply when nature is as vital as that in Sri Lanka. The question of sustainability can never be answered independently from the respective situation.

Sources and acknowledgements

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Holcim Foundation



The Holcim Foundation for Sustainable Construction promotes innovative approaches to sustainable construction. The objective of the Holcim Foundation is to encourage sustainable responses to the technological, environmental, socioeconomic and cultural issues affecting building and construction, regionally as well as globally – through a range of initiatives, including Holcim Awards, Holcim Forum, and Holcim Projects.

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