Sustainability

BLUESCOPE STEEL

Extreme Weather Events

BlueScope Steel Ltd. (BlueScope Steel) has made a commitment to continually improve the company's environmental footprint and the sustainability of its products and services.

This is the ninth in a series of technical bulletins relating to sustainability issues that directly or indirectly impact the steel value chain. In writing these bulletins BlueScope Steel wishes to inform and educate the market, based on the latest available and verifiable information.

This technical bulletin details the changes to patterns of extreme weather events across Australia that are likely as a consequence of global climate change. The expected changes are sometimes more or less pronounced depending on region, but generally it is anticipated that:

- Both day- and night-time temperatures will increase;
- Rainfall will decrease, leading to more frequent and intense droughts;
- More extreme rainfall events will likely cause more flooding;
- When they occur, tropical cyclones are likely to be more intense;
- Severe storms are likely to be more frequent;
- Severe hailstorms are likely to be more common, especially in NSW; and
- Bushfires are likely to occur more frequently.

This bulletin also demonstrates that for each of the elements of Australia's harsh climate, BlueScope Steel products offer a way to avoid or mitigate some of the impacts now, and in the future.

Other technical bulletins in this series related to climate change and extreme weather events include: 2. Urban Heat Islands.

1. Changes to Extreme Weather Events in Australia

It is now widely accepted that the changes to the composition of the Earth's atmosphere and radiation budget† due to human activities, such as deforestation, industrialisation and urbanisation has, and will continue to affect many aspects of local, regional and global climate. As well as changes in daily temperature range and average temperature, the intensity, frequency and distribution of rainfall, severe storms, cyclones, hailstorms and bushfires are all predicted to change across Australia over the coming decades[1,2]. In a report to The Australian Green House Office, Department of the Environment and Water Resources, The Building Association of New Zealand Limited (BRANZ)[1] noted the importance of planning for these unavoidable and, in some cases, unpredictable events across the built environment.

Steel products can be used in new construction and retrofit projects to help mitigate expected changes, such as

† The radiation budget is the balance between energy received from the sun and the longwave (thermal) and reflected shortwave energy leaving the Earth.

Table 1: Summary of expected changes in weather patterns across Australia that are a consequence of climate change and how BlueScope Steel products can help avoid or mitigate the effects.

CLIMATE PARAMETER		CHANGE	MITIGATION STRATEGIES WITH STEEL PRODUCTS	BLUESCOPE STEEL PRODUCTS
Temperature	Annual average	Increased temperature at most locations[1]	External roofing and cladding that is light coloured reduces the amount of solar radiation (and consequently heat) absorbed into buildings[4]. Painted steel products also have high thermal emittance, so any heat that is absorbed is re-radiated quickly when the sun sets[4]. Lightweight, low thermal mass materials respond to changing thermal conditions quickly i.e, steel structures require less energy to cool down.	• Standard COLORBOND® steel incorporating Thermatech® technology • COLORBOND® Coolmax® steel • ZINCALUME® steel • TRUECORE® steel for framing
	Maximum	Increased; more hot events at most locations[1]		
	Minimum	Increased; fewer cold events at most locations		
Humidity	Relative annual and seasonal humidity	Decreased in most areas[1]		
Rainfall	Summer	Increased in the north and east; decreased in the south[1,5]	Rain should be harvested to reduce demand from mains supply – especially in times of rainfall deficit. Harvesting also reduces stormwater flow during rain events, which may reduce the risk of flooding, erosion and landslides. Steel is impervious to water and requires less maintenance post-flood[6].	• BlueScope Water tanks • AQUAPLATE® steel • TRUECORE® steel for framing • COLORBOND® steel
	Autumn	Increased inland; decreased in the south[1]		
	Winter	Decreased in most locations; increased in the south[1]		
	Spring	Decreased in most locations[1]		
	Peak daily rainfall	Increased in most locations[1,7]		
	Daily intensity	Increased at most locations[1,7]		
Coastal Flooding	Sea-level	Increased[1]	Salt-corrosion resistant building materials are preferable[1].	• COLORBOND® Stainless steel • COLORBOND® Ultra steel
	Storm tide height	Increased in some areas		
Fires	Frequency	Increased in most areas[1]	Steel is more resistant to fire – and reduces radiation behind the line – than other materials used for the same purpose.	• Fencing manufactured from COLORBOND® steel • SURELINE® steel poles • AQUAPLATE® steel water tanks
Cyclones	Peak winds	Higher in most locations	Curved lines reduce wind loading[1,10]. High strength, lightweight materials can be advantageous in designs for storm prone regions.	• COLORBOND® steel • TRUECORE® steel for framing
Extreme Winds	Over the 95th percentile	Increased in most locations		
Hail	Frequency	Increased over Sydney; decreased in the south-east[1]	Steel roofing is less likely to be penetrated[1].	• COLORBOND® steel • ZINCALUME® steel

increased temperature, and potentially avoid catastrophic damage from severe weather events, such as hailstorms and cyclones (*Table 1*).

2. Temperature

In Australia, from 1910 to 2004, the average maximum temperature rose 0.6°C[2]; the average minimum temperature rose 1.2°C[2]; and as a consequence, the average daily temperature range has narrowed[3]. From 1957 to 2004, the Australian average shows an increase in hot days (≥35°C) of 0.10 days *per* year[2]; an increase in hot nights (≥20°C) of 0.18 nights *per* year[2]; a decrease in cold days (≤15°C) of 0.14 days *per* year[2]; and a decrease in cold nights (≤5°C) of 0.15 nights *per* year[2], resulting in fewer frost days[9].

During the eastern Australia heatwave in February 2004, approximately two-thirds of continental Australia recorded maximum temperatures over 39°C; the temperature reached 48.5°C in western NSW[2]. The January/February 2009 south-eastern Australia heatwave set many records for maximum day- and night-time temperatures, as well as for the duration of extreme heat[10].

For example, maximum temperatures in Melbourne were above 43°C on three successive days for the first time in recorded history[11] and a new maximum of 48.8°C was set for the state in Hopetoun[10]. In Tasmania (Scamander) an all-time maximum of 42.2°C was set[10] and in Adelaide a record overnight minimum of 33.9°C was set[10].

Temperature also feeds back on other aspects of climate: for example, temperature affects potential evaporation rate and humidity, which in-turn can increase the risk of rainfall deficit or drought and fire, which represents further risk to society and the built environment (see Sections 3.1 and 5).

Higher average temperatures – and in particular the increased frequency of very hot days and nights – can cause an increase in energy demand for air conditioning. This in-turn places stress on electricity generation infrastructure, and may cause an increase in heat-related stress, illness and mortality (especially in communities where many cannot afford to use energy for mechanical air conditioning). These effects on human welfare can also impact business and the wider community. For example, there is the potential for productivity to decrease if workers are unable to get adequate, uninterrupted rest due to uncomfortable conditions at night. During the 2004 heatwave, the Queensland ambulance service recorded a 53% increase in ambulance call-outs[2], which would likely have represented a material cost to the state, and placed the system – and those operating within it – under a lot of pressure.

2.1 Managing Warmer Temperatures with BlueScope Steel Products

Because of high solar reflectance, roofing and walling made from light coloured COLORBOND® steel incorporating Thermatech® solar reflectance technology; light coloured COLORBOND® Metallic steel; COLORBOND® Coolmax® steel; or ZINCALUME® steel may help reflect incoming solar energy away from buildings, potentially reducing reliance on mechanical air conditioning, making comfort affordable and reducing pressure on the electricity grid. For example, a new COLORBOND® steel roof in the colour Surfmist® has a solar absorptance of 0.318[‡], meaning that only 31.8% of incoming solar radiation can be absorbed

‡ This value does not relate to the COLORBOND® Ultra steel or COLORBOND® Stainless steel ranges. The solar reflectance value is based on as-new/unweathered product produced in Australia in September 2008.

into the building. The remaining 68.2% of incoming radiation is reflected away from the building – and the community – and therefore cannot be converted to heat in the building. The US EPA reports that the surface of a light coloured roof can be up to 39°C less than a dark coloured roof[4]. COLORBOND® Coolmax® steel takes this concept even further. Developed specifically for commercial and industrial buildings, COLORBOND® Coolmax® steel in the colour Whitehaven™ has a solar absorptance of only 0.23*, which means that 77% of incoming solar radiation is reflected away from the building.

Meeting peak summer electrical loads is already a problem for most Australian grids: reducing demand at peak time may negate the need to invest in additional infrastructure or to place limits on supply. In the residential sector the early evening is a time of peak demand, so reducing the need to use air conditioners to cool homes at the end of the day is potentially significant. Because painted steel products have *high thermal emittance*, roofs made from COLORBOND® steel allow any energy that is absorbed into the building during the day to be re-radiated quickly once the sun sets, thereby helping to reduce peak energy loads. Further, cooling via re-radiation, rather than using a mechanical air conditioner, may represent a financial saving to occupiers, meaning that a home that is cool and comfortable to sleep in is more affordable.

The fact that steel is also lightweight – or has *low thermal mass* – is also beneficial for homes occupied intermittently. Steel construction responds quickly to changes in thermal conditions, which means that buildings can be cooled quickly at the end of the day.

3. Rainfall

There is general consensus that over the 20th century Australian average and extreme rainfall has increased[7]. However, due to a shift in climate around 1950[2], there is a second set of trends appearing[7] that may be more indicative of the future. From 1950, the north-western two-thirds of Australia has seen an increase in summer monsoon rainfall, while southern and eastern Australia have become drier[5]. Extreme daily rainfall (rainfall in the 95th and 99th percentile) has also increased in north-western and central Australia, and over the western tablelands of NSW[7]. However, rainfall has decreased in the south-east, south-west and across the central east coast[7]. Collectively, this means that most of the top half and centre of Australia may be prone to more flood events in the future, while the southern states may be generally more prone to rainfall deficits and droughts.

3.1 Drought

Droughts have reportedly become hotter since about 1973[2], because temperatures have increased for a given rainfall deficiency. Droughts are not only financially and emotionally devastating for the communities across which they occur, they are extremely costly for the nation as a whole. The droughts of 1982-1983, 1991-1995 and 2002-2003 cost US$2.3 billion, US$3.8 billion and US$7.6 billion, respectively[2]. Note that all costs in this document are adjusted to 2002-2006 values in US$, as per the Report of Working Group II to the Fourth Assessment of the IPCC[2]. This standardisation is intended to allow for direct comparison of the financial cost of severe weather events that have occurred across Australia (and globally) over time.

Further, as it is the viability of agricultural areas that is most likely to be affected by drought conditions, this aspect of climate change directly impacts the sustainability of Australia as a whole, as availability (and cost) of basic food supplies may be affected.

3.2 Flooding

Floods may be the consequence of both increases in mean rainfall, and in particular, any increase in rainfall intensity: intense rain events are more likely to result in high levels of runoff, erosion,

‡ The solar reflectance value is based on as new/unweathered product produced in Australia in 2010.

landslides and flooding. Flooding, in particular, occurs if stormwater systems cannot handle the volume of water, or are blocked by sediment or other debris carried with the stormwater.

Flooding can erode building foundations, and if water penetrates the building envelope, there is the potential for significant damage to the building fabric and occupiers' possessions or plant.

3.3 Water Conservation and Management with BlueScope Products

BlueScope Water tanks – made from AQUAPLATE® steel – are designed for *rainwater harvesting* for potable and non-potable purposes: storing water when it is available can help alleviate supply deficits when water is scarce. Harvested rainwater can be used for non-potable purposes such as irrigation and toilet flushing, which reduces demand for water from mains supply. Further, because the interior surface of AQUAPLATE® steel tanks are coated with food-grade polymer, if the appropriate rainwater harvesting accessories are used, harvested water may be suitable for potable purposes too.

Harvesting also reduces the amount of water that has to be processed across a catchment during and after rainfall events: in areas where rainfall intensity is increasing, this reduction in flow may prove the difference between maintenance of the status quo and severe effects.

If water is diverted into a tank it is not able to:

- erode valuable topsoil;
- water-log the soil, potentially leading to subsurface instability and landslides;
- carry sediment and debris into receiving waterways, which can negatively impact biota in these environments;
- move debris into stormwater drainage systems or receiving waterways, potentially causing blockages that can lead to surface flooding; and
- erode foundations of buildings in the flow path.

Steel is *strong* and *impervious* to water: should severe flooding occur, steel cladding and framing will not absorb water the way other building materials can, and thus will not be left susceptible to warping, cracking, termite attack or rot. After a flood steel framing should be exposed, allowed to dry and cleaned[6]: this process is far simpler, and does not involve potentially replacing entire building components, as is the case for some other materials[6].

4. Coastal Flooding: sea-surface height, storm surge and sea-level rise

Coastal flooding is often caused by changes in sea-surface height and storm surges. Severe storms – which are likely to increase under climate change scenarios (see Section 6) – can produce temporary increases in sea-surface height due to the wind profiles they create and the effect of on barometric pressure[2]. Coastal geometry and the presence and width of the continental shelf also affect the likelihood and severity of coastal flooding: the latter plays a crucial role in determining the relative contribution by waves and storm surge[2]. Wide, shallow continental shelves favour large storm surges, while narrow or non-existent shelves favour large waves[2].

Sea-level rise is another of the consequences of climate change that is already manifest – from 1920 to 2000, relative sea level around Australia rose by 1.2 mm *per* year on average[2] – and is predicted to continue to rise[1]. A permanent rise in sea-level increases the risk of flooding during less severe storm events, and may increase the extent of flooding during severe events. When the flooding caused by Cyclone Wanda across the Gold Coast region in January 1974 was extrapolated to 2050 conditions, including a 10-40 cm rise in mean sea-level, 3-18% more dwellings and people were affected[12 in 2].

Damage to the built environment from extensive coastal flooding is similar to that caused by inland flooding (see Section 3.2): erosion of foundations; damage to building fabric; and loss of possessions or equipment housed in the building. However, the salt deposited by storm surge and large waves presents a different challenge to the built environment: while not as devastating as a flood or inundation event, salt deposits negatively affect the durability of most building materials.

As the frequency of occurrence, and the extent inland that storm surges reach increases, more buildings will be affected by salt deposition and erosion.

4.1 Salt (Corrosion) Resistant BlueScope Steel Products

BlueScope Steel produces a range of products that are manufactured to withstand severe environmental conditions, including those in marine, industrial and intensive farming locations[13]. Pre-painted COLORBOND® Stainless steel incorporates a 430 grade stainless steel substrate, and thus is particularly resistant in marine environments (*Table 2*). COLORBOND® Ultra steel has been designed to offer improved corrosion resistance compared to standard COLORBOND® steel in marine environments (*Table 2*).

Table 2: Recommended BlueScope Steel Product Guide for Roofing in Marine Environments[13].

MARINE ENVIRONMENT SEVERITY	DISTANCE FROM BREAKING SURF	RECOMMENDED ROOFING PRODUCT
Very Severe	0-100m	COLORBOND® Stainless steel
Severe	101-200m	COLORBOND® Ultra steel
Marine	201-400m	COLORBOND® steel

NB: Absolute performance is subject to local conditions (e.g. prevailing winds) and unwashed areas.
The above data applies to roofing product only.
The above data applies to salt marine influences only.

5. Bushfires

The potential loss of capital and human life due to bushfires is already significant, and may increase under future climate change scenarios: fire intensity and frequency are predicted to increase as a function of the increase in frequency of very hot days, and the decrease in humidity. In the ACT, BRANZ predicts an increase in the Fire Danger Index of between 5 and 20% by 2070[1]: fires in the Canberra area have already had devastating consequences. The January 2003 fire resulted in US$261 million[§] damage; destroyed approximately 500 houses; killed four people and injured hundreds[2]. More recently, bushfires in Victoria in early February 2009 left 173 people dead and thousands homeless.

It is not hard to conceive that some building materials, such as steel and concrete, will resist fire better than alternative materials: BRANZ[1] cites the use of fire-resistant building materials and the installation of sprinkler systems as the adaptation strategy for bushfire in the residential sector.

5.1 BlueScope Steel Product Performance in Simulated Bushfire Conditions

In conjunction with the Bushfire Co-operative Research Centre Research (Bushfire CRC), BlueScope Steel has investigated how steel products (fencing, power poles and water tanks) perform in bushfire conditions. Results support anecdotal evidence that steel products resist fire better than other materials used to perform the same function.

The first of the studies investigated the performance of the most common residential boundary fencing systems – pre-painted and metallic-coated sheet steel, hardwood and treated pine – used in urban and urban–rural interfaces in the built environment across Australia[14]. The research investigated the potential for using fencing systems as protection for residential buildings against attack from radiant heat, burning debris and flame impingement during bushfires[14]. Because it is *non-combustible*, COLORBOND® steel performed the best overall[14]: it maintained structural integrity, acted as a heat barrier under all experimental exposure conditions and did not spread flame laterally or contribute to fire intensity during exposure[14]. The radiation levels immediately behind the fence were reduced to less than 5 kW/m^2 during all radiation exposures, and the radiant heat exposure on a structure 9 m from the fence was reduced by at least a factor of two[14]. It can therefore be concluded that the behaviour of a COLORBOND® steel fencing system may contribute to reducing the risk of loss of life and/or property during a bushfire.

The second study also found that steel products maintain their integrity during bushfire conditions. When exposed to bushfire passages involving pre-radiation and ground fuel attack, as well as flame immersion, radiant heat and ground fuel attack, SURELINE® power pole systems maintained their integrity and serviceability[15].

In the third study, plastic and metal water tanks were exposed to ember, radiation and flame attacks – commencing with a *low* category attack and progressively increasing to *medium*, *high* and *extreme* conditions[16]. Observations focused on the propensity of the tanks to:

- ignite;
- lose integrity; and
- act as a mechanism for spreading flames[16].

Overall, metal tanks performed better than plastic tanks: metal tanks maintained their structural integrity through all fire exposures tested[16]. Minor leaks were observed in the metal spiral tanks (spiral wound galvanised COLORBOND® AQUAPLATE® steel) only after 30 minutes of flame immersion[16]. Small leaks, with a low rate of water loss – less than two litres *per* minute – were observed from some of the seams of the conventional metal tanks (COLORBOND® AQUAPLATE® steel) after the flame emersion and structure exposure simulations[16]. The ZINCALUME® steel bladder also sustained damage after flame and structural exposure, however, the leaking was found to not significantly affect the capacity of the tanks to be used for fire-fighting during a bushfire[**,16].

Conversely, the polyethylene tanks were found to be involved in the combustion process during the leaf litter/ember exposure. The combustion remained localised and persisted for up to 22 minutes with a relatively small amount of leaf litter: if higher levels of leaf litter were present, loss of integrity of the tank may occur[16]. During higher level exposures, the tank portion above the waterline melted and was involved in flaming combustion[16]. Below the waterline, surface flames were observed, and in the more intense exposures, the tank wall swelled under the static pressure load of the water due to softening of the outer surface of the plastic[16]. In a number of cases this distortion led to catastrophic rupture at the swollen tank section[16].

Tight-fitting hinged or roll-down shutters – made of non-combustible material such as steel – can also provide superior

§ All costs are adjusted to 2002-2006 values in US$ as per the Report of Working Group II to the Fourth Assessment of the IPCC[2]. This standardisation is intended to allow for direct comparison of the magnitude of the events that have occurred.

** Note that simulated testing did not include testing as to whether the water remaining in the tanks post-fire was of potable quality.

protection for windows as, when closed, they reduce the horizontal projection available for debris accumulation, remove one combustible surface in a re-entrant corner and provide a radiation and ember barrier[17]. As well as protecting the glazing, shutters usually cover and protect windowsills, which is advantageous in the case of timber windowsills, which – like all horizontal timber elements of a house – are vulnerable to ember ignition[17].

6. Tropical Cyclones and Severe Storms

The frequency of tropical cyclones across Australia is reported as stable[2] or decreasing[1], while the intensity of cyclones is reportedly increasing[18,19]: cyclone intensity is predicted to continue to increase into the 21st century as a consequence of climate change. The studies cited in *Climate Change in Australia*[19] all report a marked increase in severe, Category 3-5 storms: high-resolution modelling predicted an increase in intensity of the most extreme storms for 2030 and 2070 of 60% and 140% respectively[19].

Both the IPCC[2] and BRANZ[1] report that there has also been an increase in the frequency of intense storm systems (systems with very low central pressure): under climate change scenarios, wind speeds, extreme rainfall events and intense local storms are predicted to generally increase across Australia, potentially most marked in the north-east[1].

Severe storms and tropical cyclones often cause significant disruption and/or damage to homes and community infrastructure such as hospitals and schools; businesses and industrial sites; utilities and infrastructure (including road, rail and air transport systems and communication systems); crops and production forests; and native habitat and beaches. Across the built environment, the loading by pressure forces can lead to structural failure e.g. removal of individual tiles or iron sheeting through uplifting of entire roofs or walls; general structural failure of building components leading to potential total building collapse; impact damage from flying debris; and rain/moisture penetration leading to internal damage (see Sections 3.2 and 4).

The financial cost and insurance liability represented by severe storm and cyclonic events is also significant – and increases with storm intensity. The damage caused by tropical cyclone Larry across Queensland in 2006 totalled US$263 million[§]: the south-east Australia storm in 2005 led to insurance claims of almost US$152 million[§,2].

6.1 Withstanding Cyclones and Storms in the Built Environment

Designing – or altering – buildings to improve their aerodynamics can reduce wind loads[8]: curved corners and minimal eave overhang are two design solutions[1,8]. Curved corners are likely to be preferable in most regions, as eaves offer protection from driving rain and reduce solar gain[1]. Because of the inherent *malleability* of steel, BlueScope Steel products can be prefabricated with curvature that is difficult, or impossible, to achieve with less flexible alternative materials.

Steel frames can be engineered to sustain high wind speeds and can be easily and effectively tied-down: steel roofs have also been found to be more impact resistant than other comparable roofing materials[1] (see Section 7.1). The *lightweight* nature of steel products are also reported to reduce damage to other buildings and infrastructure, should building components become detached during a storm event[20].

7. Hail

Hailstorms that cause damage to – and result in the need to replace – slate and tile roofing components already occur as often as every 5 years across Sydney[21] (*Table 3*). It is likely that the frequency and intensity of severe hailstorms will increase across the Sydney region in the coming decades[1,21] as severe storms increase.

Table 3: Current frequency of hailstorms across Sydney of the severity to break different roofing materials[21].

ROOF MATERIAL	FREQUENCY OF HAILSTORMS OF THE SEVERITY TO BREAK ROOFING MATERIALS (SYDNEY)
Glass	5 years
Plastic	5 years
Old slate	15 years
Old tiles	15 years
New concrete tiles	20 years
New terracotta tiles	20 years
New slate	50 years

NB: Steel was not included in this analysis, as it is not considered to be linked to the issue of brittle buildings in Sydney by the authors[21].

The Sydney hailstorm in April of 1999 is classified as one of the most expensive natural disasters in Australian history[22], costing US$1.7 billion[§], of which US$1.3 billion[§] was insured[2]. This highlights the risk that the consequences of climate change present to the insurance sector in particular.

7.1 Hail Resistant Roofing

Hail has the potential to cause such extensive damage because the stones crack or penetrate roofing materials, allowing water ingress into the building. According to research by NRMA Insurance[1] undertaken after the Sydney storm, and ongoing research at the University of Western Sydney[21], steel roofs typically offer better protection in hailstorms than concrete, slate and terracotta tiles. In the NRMA experiment, manmade hailstones were fired at corrugated steel sheets and concrete, slate and terracotta tiles: it was reported

[§] All costs are adjusted to 2002-2006 values in US$ as per the Report of Working Group II to the Fourth Assessment of the IPCC[2]. This standardisation is intended to allow for direct comparison of the magnitude of the events that have occurred.

that corrugated steel performed best overall, withstanding hailstones up to 10 cm in diameter[1] (*Table 4*). Data from actual storm events across Sydney is in agreement with the NRMA study[21] (*Table 4*).

While smaller hailstones can dent steel sheets, they are not penetrated as easily as tiles, so are less likely to allow water into the building, thereby reducing damage and insurance and clean-up costs from severe hail events. The University of Western Sydney study reportedly found that tile roofs are ***too flimsy and unstable to withstand the onslaught of a summer storm season*** in Sydney[21]. Furthermore, if a steel roof is damaged, it is likely to still be weather-tight, and can therefore be replaced at a later date and at a lower cost than immediately after the storm, when shortages of labour and materials can increase costs.

8. Emergency Housing

As severe weather events increase, there will, unfortunately, be the need for more temporary and emergency housing. BlueScope Steel has been working with the Red Cross in Asia for the best part of a decade, developing and installing semi-temporary housing in areas that experience regular flooding, and responding to severe events with emergency accommodation.

Table 4: Performance of different roofing materials in simulated[1] and actual Sydney hailstorm events[21].

ROOF MATERIAL	DIAMETER OF HAILSTONE		
	Actual Damage Point[21]	Actual Breaking Point[21]	Simulated Breaking Point[1]
Corrugated steel sheets	*	*	10 cm
New slate	5-6 cm	7.5-8.5 cm	*
New concrete tiles	5-6 cm	6-7.5 cm	7 cm
New terracotta tiles	5-6 cm	6-7.5 cm	7 cm
Old terracotta tiles	4-5 cm	5-6 cm	5 cm
Old slate	4-5 cm	5-6 cm	5 cm
Glass	*	3-4 cm	*
Plastic	*	3-4 cm	*

NB: * indicates materials for which data is not reported in these studies.

8.1 Floods: South-East Asia

BlueScope Steel already has experience in working with, and in, areas that experience extreme events. Because steel products are *strong and lightweight*, they have proven ideal for use in flood prone areas in south-east Asia.

In response to a brief from the Red Cross, engineers from BlueScope Lysaght Vietnam designed LYSAGHT PEBLITE™ (a pre-engineered building). In 1999, 2500 houses had been supplied across Vietnam's central and the Mekong Delta regions when the area experienced the worst flooding in the nation's history[23]. Only two of the structures were damaged, one in exceptional circumstances – 34 people took refuge on the roof for several days because it was the only structure left standing in the neighbourhood[23]. BlueScope Lysaght subsequently worked with the Red Cross and AusAid in the Mekong to develop prototypes for new school buildings and clinics. The buildings now provide thousands of children with regular schooling, as well as serve as emergency/rescue buildings during the flood season[23].

In 2001, floods devastated north-east Thailand, killing dozens of people and leaving thousands homeless: the Thai Red Cross issued an urgent appeal for temporary housing for the people of Petchaboon Province, where hundreds of traditional houses had been destroyed[23]. BlueScope Lysaght

Figure 1a: Built-in mezzanine floor for flood protection.

Figure 1b: Free Standing with no walls for easy replacement.

Thailand drew on the Vietnamese experience, and within days delivered a proposal that met Red Cross requirements. Within weeks 173 low-cost houses had been delivered, and subsequently BlueScope Lysaght designed and supplied four elevated clinics to the region[23].

The challenges of building in these environments generally, and especially under emergency conditions, include that:

- a lot of buildings are needed very quickly;
- buildings have to be able to be extended upon by locals;
- houses are to be supplied without walls, and are to be capable of accommodating a wide range of local walling materials;
- the frames need to be strong enough to withstand floods;
- the frames need to be easy to assemble with minimal tools and no electricity; and
- because many of the sites are remote, the materials need to be able to be delivered by motorcycle, bicycle, canoe, buffalo and even carried in by hand[24].

Figures 1a and *1b* are examples of the designs that have been developed for flood-prone areas in Asia[24]: the steel frame is designed to withstand the force of flood waters, while walls – made using traditional (or available) materials and techniques – are replaced as necessary after each event.

The mezzanine in *Figure 1a* provides a refuge for people and possessions during floods. Both structures are quick and easy to erect: because they are prefabricated they require limited tools, resources and experience to assemble[24].

9. Counting the Cost of Extreme Weather Events

Severe weather events represent a risk to lives and livelihoods, as well as property and infrastructure – risks that are likely to increase because of climate change. As documented in the preceding sections, steel products can be incorporated into buildings that are more likely to withstand severe storms and cyclones; which mitigate effects such as increased temperature and water deficit; and that provide emergency shelter.

Losses to the global economy due to climate change exceeded US$200 billion in 2008 – the third highest annual level recorded[25]. Europe's largest insurer, Allianz, stated that climate change stands to increase insured losses from extreme events in an average year by 37% within a decade, while losses in a bad year could reach US$400 billion[26 in 25]. The data standardised and reported by the IPCC[2] (*Table 5*), clearly detail the financial cost and insurance risk associated with extreme weather events to-date in Australia: this risk is just one of the reasons that strengthening the built environment, and incorporating sustainable solutions into all building projects, is essential.

Table 5: Summary of the cost of recent severe weather events[2].

SEVERE WEATHER EVENT	STANDARDISED COST (US$)
Drought (2002-2003)	7.6 billion
ACT fire (2003)	261 million
Tropical Cyclone Larry (2006)	263 million
South-east Australia storm (2005)	152 million
Sydney Hailstorm (1999)	1.7 billion

NB: All costs are adjusted to 2002-2006 values in US$ as per the Report of Working Group II to the Fourth Assessment of the IPCC2 to allow for direct comparison of the magnitude of the events that have occurred.

The data in *Table 5* indicate that the biggest financial costs to-date have been accrued because of drought: however, because droughts extend over many months or years, it can be argued that hailstorms represent the largest risk (*Table 5*). From the data presented in *Table 4*, it is clear that steel products offer the best protection to property, people and possessions during hailstorms, and therefore should be considered the preferred roofing material by all designers and builders in hail-prone regions.

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