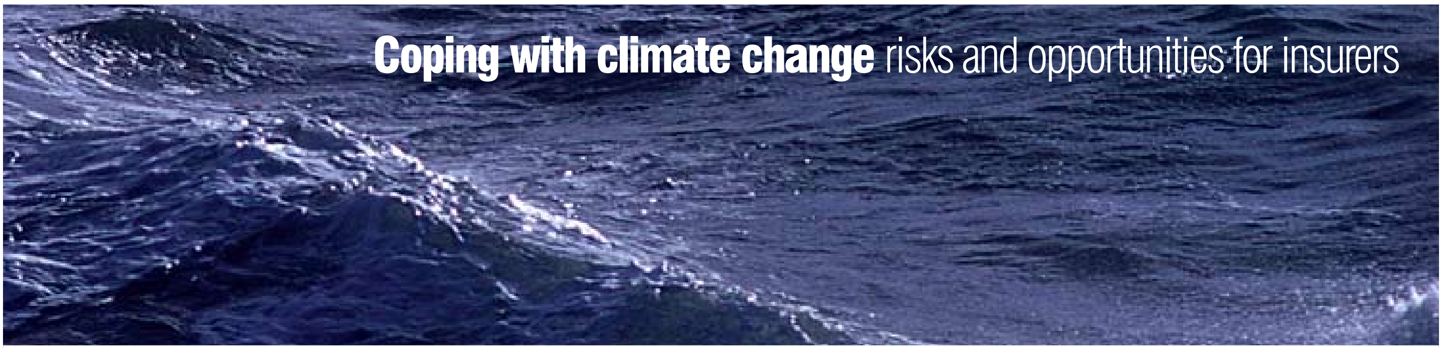

Chapter 11
Construction

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11.1 Overview summary

This chapter examines the effects of climate change on construction risk, but also how construction works significantly alter pre-existing environmental conditions. The focus of attention is major contracts, since smaller-scale work has similar considerations, and also is covered by implication, in the property chapters of this study. Central to this discussion are sound planning and risk management in the context of climate change. Design, materials and workmanship are major concerns for insurers since failure can involve catastrophic loss, and complex claims issues regarding the scope of insurance protection.

Escalating population growth in very concentrated areas increasingly encroaches on marginal land and potable water resources. Major conurbations come to rely entirely on vulnerable external supplies of resources and themselves impact upon the natural environment.

The problem is how to maintain development within acceptable insurable risk parameters. Short term social, commercial, economic and political pressures may outweigh scientific caution and environmental concerns. Yet construction generates a fundamentally long term risk for insurers and society. Thorough risk management is therefore vital in project planning.

The ultimate effect of environmental change becomes ever more difficult to assess. Global climate change means that past statistics at best serve as a very rough future guide, with risk prediction scenarios increasingly open to considerable doubt.

How do we accommodate:

- the need to control greenhouse gases (GHG's)?
- a rapidly increasing global population in numbers and mobility?
- the upsurge in emerging economies?

Insurers have always faced the challenge of a Construction Industry trying to do more with less, in new ways. Now the pace of change is accelerating, the climatic environment is changing, and low emissions requirements present a new constraint, since Construction constitutes a major source of CO_2 emissions, e.g. through cement production (IPCC,2007).

11.2 What is climate change?

Climate may be defined as the general weather conditions prevailing in a designated area over a prolonged period, but it can equally extend to a wider interpretation – a prevailing trend or public attitude. Both are very relevant in the context of global construction projects. The IPCC (2007) report uses "climate change" to refer to any change in climate over time, whether due to natural variability or as a result of human activity.

Weather variables are a particularly high risk factor when drawing up the project management profile, not only for the construction phases but the planned lifespan of the proposed works. Potential climate change scenarios must be carefully assessed to evaluate anticipated change features, and select appropriate safeguards. In some cases there is still considerable uncertainty, e.g. over future precipitation or storminess. Wider safety margins seem more prudent than just ignoring the issue. This applies to climate change at the global perspective and at a very localised area. Interestingly the fundamentals may be very similar.

The '3C' concept[1]

Because it has become so significant, there is a need to differentiate between Natural Climate Change, the past record of which is primarily contained within the geology around us, and Forced or Anthropogenic Climate Change influenced by civilisation. In the same way it is necessary to define another concept: Construction Climate Change, or '3C' because it is a locally important factor. '3C' may be defined as the change effect(s) on the local or regional environment derived from construction operations or developments.

Note: '3C'

- May have consequential effects distant from the construction itself;
- Can be cumulative. Hence past and future effects need evaluation;
- May create dependence on a non-natural environment;

[1] Term adopted by the author to describe the local environmental impact resulting from construction development as distinct from global climate change.

- May significantly and irrevocably alter the pre-existing natural state. Only in very marginal cases can an earlier natural state be regained;
- May intensify, or at the other extreme negate, natural climatic or geological phenomena;
- May cause significant waste disposal and pollution problems.

There are many examples of '3C' and its profound influence on the local environment (Diagram.1). City areas, increasingly high-rise dominated, produce much higher temperature levels, often several degrees higher than those experienced 'out of town' (Box 4).

Global construction development by its very nature changes the environment, including the climate. Local works can have a similar effect on the existing micro-climate and natural bio-diversity as macro developments covering a much greater ground area (see Box 1). The '3C' impact on a local or regional environment can far outweigh natural variation.

Construction work needs to withstand a potentially very varied and uncertain climatic impact. The longer the use period the greater the climatic influence exerted. Much will centre on design flexibility, suitability of materials used and a skilled workforce during the construction phase. Thereafter sound standards of upkeep and maintenance must be observed.

Diagrams 2 and 3 illustrate potential risk areas, any one of which might have a bearing on future events. The strength of any structure may heavily depend on its weakest point.

Construction-induced changes to drainage can be critical, for example, changing '3C' conditions can quickly impose demands on drainage not anticipated when installed perhaps over a century ago. Linking new development to an existing adequate drainage infrastructure requires careful capacity assessment.

Removal of boundary hedges or ditches to accommodate farm mechanisation will result in accelerating run-off when heavy rain falls with flooding potential. Confinement of natural drainage is a common contributing cause. Examples are numerous (Diagram.3). On a much greater scale deforestation within a river catchment area may have considerable impact on installations downstream.

Large concrete or tarmac areas create drainage problems. Water will find its own level. Transfer 'downstream' only solves the local problem at the expense of another location. Ground water flow may be greatly influenced by environmental change and precipitation by atmospheric conditions.

Motorway, rail and other embankment works may act as temporary dams. A natural equivalent which may increase with climate change is a storm surge barrier. In coastal areas a temporary uplift in sea level due to an onshore wind can act as a temporary wall against land-based outflow.

A direct comparison needs to be drawn between the naturally existing environment before changes take effect (Diagram 2) and the potential result of construction development change (Diagram 3). Some change will be short-lived, e.g. de-watering[2] during construction with pre-existing conditions expected to return. Other changes will be permanent. For practical purposes each development builds on changes caused by earlier works.

BOX 1
Byrd Close – A micro '3C' event with macro implications

To satisfy demand, low rise housing for elderly residents was built on a centrally located water-meadow site bordering the village pond. The existing outflow stream was piped downstream. Drainage was installed to accommodate run-off from the built-over tarmacadam area. A concrete boundary wall provided security.

Two months following occupation heavy rainfall caused 'flash-flood conditions'. The pond quickly overflowed, the site drainage overwhelmed and rising floodwater was accentuated by the retaining wall acting as a dam until it failed with water passing through neighbouring properties. Without the changed environment, excess water would temporarily have saturated the ground – used for cattle grazing – and quickly drained via its pre-existing natural course.

This type of incident was widely noted in the Pitt Review (2008), and clearly these circumstances apply to much larger regional developments. Adequate well-maintained drainage is of prime importance.

[2] The procedure to achieve a dry working area, e.g. pumping. This may have serious implications with respect to surrounding property if all necessary precautionary measures, are not undertaken. Provision of standby facilities becomes an essential insurance requirement.

Diagram 1: examples of '3C' construction climate change

Project *	Potential Advantages	Potential Disadvantages
Dam **'3C' Effect – Unnatural Environment**	• Water conservation • Energy creation • Flood relief • Irrigation • Navigation via lock system • Enhanced value of downstream earlier floodplain land/property	• Evaporation loss • Effects on geological environment • Silting up of impounded storage • Major biodiversity change • Downstream delta estuary erosion with saline intrusion • Loss of nutrient material retained by impounding • Salinisation of irrigated land • Conflicting interests, e.g. energy v. irrigation, etc. • Population displacement
Water (Potable) Transmission **'3C' Effect – Unnatural Dependent Environment**	• Arid location development creates new self sufficient area • Avoid use of local mineralised water	• Total dependency on continuous fresh water supply • Costs of providing and maintaining supply from source • Supply based on non natural source, e.g. desalination
Coastal Protection (Sea Walls, Barriers, etc) **'3C' Effect – Delay In Natural Change Effect**	• Continued use of threatened land • Security of coastal installations, e.g. ports, tourist facilities, etc. • Township, residential housing • Extreme flood barrier to avoid saline intrusion	• Increasing maintenance cost • Frequency of updating works • Loss of seaward natural defence – e.g. salt marsh (Box 5) • Biodiversity threat, i.e. SSSI areas • More erosion of non-protected coasts ** • Land drainage subsidence
High Rise Buildings **'3C' Effect – Heat Island and Wind Tunnel**	• Intensive use of prime land site • Concentration of services, utilities, etc • Prestige – WTC 9/11 has not deterred the race to achieve the world's highest building – front runner currently Burj, Dubai	• Fire, terrorism, security • Evacuation scenarios • Overall logistics – access • Lack of affordable low-rise housing • Increased travel and community breakdown

* Each project will have different scenario benefits and detrimental effects.

** Protection for one location where coastline subject to littoral or longshore drift will generally starve areas down-flow of sediment and increase erosion vulnerability elsewhere.

Diagram 2: Natural hazard consideration guide

	1	2	3	4	5 *	6
Earthquake	✓			Tectonic movement, shock, tremor	**P**	✓
Volcanism	✓	✓		Fire, ash, lava, gas outburst	**P**	✓
Tsunami	✓			High speed, long wave length	S	✓
Landslide	✓		✓	Unstable slope failure, avalanche	**P** S	✓
Flood	✓	✓	✓	Inundation from sea, river... storm event	**P** S	✓
Sea Level Rise	✓	**D**	✓	Isostatic, global warming...	**P** S	✓
Coastal Erosion	✓		✓	Include accretion, ongoing, stabilisation?	S	✓
Groundwater	✓		✓	Fluctuating, mineral salt content?	**P**	✓
Drainage	✓		✓	Restriction, blockage or failure...	**P**	✓
Storm		✓		Hurricane, typhoon, tornado, cyclones, etc	**P**	✓
Precipitation		✓		Seasonal rain, hail, snow, sleet, moisture	**P** S	✓
Temperature	**D**	✓	✓	High/low differentials, humidity	**P**	
Landfill + Waste Land	✓		✓	Compaction, pollutants, toxic gas emission, methane, radon... regulatory compliance – liability exposures	**P**	**D**
Contamination	✓		✓	Geologically secure containment	**P** S	**D**
Infestation	**D**		✓	Wet/dry rot, woodworm, termites...	**P** S	
Weathering	✓	✓		Acid rain, property of resistance to...	S	**D**
Wildfire		✓	✓	Drought areas	S	
Lightning		✓		Wildfire cause	**P**	
Aggregates	✓			Suitability for purpose location and ground conditions	**P**	**D**
Subsidence + Heave	✓		✓	Foundation adequacy. Movement, settlement. Differential or overall...	S	✓
Collapse	✓		✓	Unexplained? Result of failure, defect...	S	✓

1 Geological including hydrology, etc. (ground surface and below)
2 Meteorological – atmospheric (above ground level)
3 Environmental, non-natural forcing
4 Brief summary illustrations
5 **P** = Proximate cause[3] } distinguish the original cause P as distinct
S = Effects arising from P event } from consequential or secondary causation S
D = Dependent on circumstances
6 High risk exposures subject to specific conditions or high excess under CAR cover

* It is essential to appreciate ‘P’ the dominant cause as distinct from ‘S’ being secondary or consequential causation. Some hazards may be either ‘P’, or ‘S’ following another ‘P’ exposure, e.g. Flood ‘S’ may follow after Hurricane ‘P’.

Diagram 2 lists many non-climatic risks, because climate change, and localised ‘3C’ effects due to individual projects, can significantly alter the risk profile for those other hazards.

[3] The dominant cause which sets in motion a train of events leading to a loss. There is a direct, but sometimes lengthy, link between the proximate cause and the resulting loss. Where policy cover is limited to specific risks or specific exclusions apply, determining proximate cause and hence scope of protection provided or excluded is vital.

Diagram 3: '3C' Human influenced hazard consideration guide

	1	2	3	4	5
Tectonic Movement	✓	D		Able to withstand maximum shock effect. Lightweight flexible structure? Groundmass constituency critical. Rock/Alluvium/Silt/Made up Ground particularly where soil moisture content changes due to climate change	D
Landslide (Non Tectonic)	D		✓	Removal of support. Liquefaction due to water inflow Aberfan Disaster (21.10.66) (See Box 2.)	✓
Flood	✓	D	✓	Blocked or restricted drainage. Inundation due to lack or inadequacy of defence – Thames Barrier (see Figure 5)	✓
Sea Level Rise	✓	✓	✓	Inevitable long term effects. Adequate defence for extreme event – Managed coastal retreat option	✓
Coastal Erosion	✓		✓	Predictable with sudden event, e.g. cliff collapse. Temporary preventative measures – Effects of offshore dredging and longshore drift	✓
Groundwater	✓	✓	✓	Geochemical reaction of mineralised water London Water Table Is Rising	✓
Drainage	✓		✓	Interference with natural system. Land drainage settlement. Constricted river flow. Scouring infrastructure capacity failure – Mississippi drainage levee protection	✓
Storm	✓	✓	✓	Able to withstand maximum wind load expectancy – May only mitigate damage such as from tornado	✓
Precipitation	✓	✓		Water proof 'umbrella' adequacy. Load factor for snow, ice build-up, hail, weathering	✓
Temperature	D	✓		Condensation humidity creation. Expansion/contraction differentials and compensatory measures Buckling Failure. Effects of Direct Sunlight	✓
Land Reclamation 'Brownfield' Site			✓	Effects of 'trace' pollutants/contamination. Clean-up costs and site certification. Past use. Landfill, industrial/commercial use – A continuing liability exposure	D
Infestation	✓	✓	✓	Counter-measures to avoid. Damp moisture, mould Adequacy of proofing	✓
Weathering		✓	✓	Avoidance of inferior or incompatible components. Abnormal wear, tear or depreciation	✓
Wildfire			✓	Arson. Malicious or negligent action – Australian power line failures	✓
Lightning				Conductor protection, power surge avoidance	D
Aggregates	✓	✓		Correct specification compliance – Compatibility analysis from source. Analysis of recycled material	
Subsidence + Heave	✓		✓	Artificial planting or protected tree growth. Differential settlement. Foundation adequacy. Water-table variance May arise from old mining operations, area settlement from drainage. Loss or damage to underground services, e.g. pipelines, drains, etc.	✓
Collapse *	✓	✓	✓	Inherent defect. System failure – Unexpected climatic stresses	

1 Structural design **2** Materials suitability **3** Environmental influence
4 Brief summary illustrations **5** Climate change variation factor

* Latent Defects Insurance generally limited to collapse risks and by extension failure of the waterproofing umbrella, subsidence and heave.

In relation to Diagram 3 several headings may need be considered, e.g. epidemic spread due to faulty drainage, exacerbated by heavy rain and localised flooding. Similarly with pollutants, toxic waste, etc. A very local outbreak cause might rapidly have global effects – export embargo and movement controls.

Diagrams 2 and 3 set out those construction risk areas encountered and which need evaluation dependent on risk location(s) and existing environment. Foreseeable change and its implications on the existing environment must be accounted for, e.g. drainage patterns. Each project needs analysis based on its individual merits (see Box examples).

To fully evaluate underwriting risk or to assess indemnity in the event of loss or damage a good knowledge of both natural and non-natural causation is essential. All need careful consideration particularly where the scope of cover is restricted by policy limitation, e.g. application of self-retained deductible or in the case of latent defects limited to specific risks.

Proximate cause can be a central issue in the event of dispute. Large claims in particular can involve very complex argument as to cause and effect. Conflicting contributory factors may well exist. Failure to appreciate the potential impact of climate change variables and provision within the project planning and its implementation increase insurers' potential future risk profile. '3C' impacts are a vital factor in determining insurance terms and costings.

To determine causation when considering a combination of deficiencies in design, materials or expected work standards has always been a major CAR insurance problem area, similarly, to differentiate between natural and non-natural cause.

Loss or damage may result from a quite insignificant occurrence which 'triggers' a series of events to reach a final catastrophic conclusion. Groundmass saturation brought about by changed weather patterns and higher precipitation levels will greatly increase the risks associated with land slippage, considered a major geological consequence. Earthquake shock can greatly magnify the potential outcome. Previously dry areas may disclose unforeseen aquifers, springs or 'slip' surfaces.

Drainage systems can be seriously damaged as a result of unforeseen climatic change, e.g. subsidence, heave or ground movement. Non-natural causes can point to inadequate or blocked drainage.

Pipelines are susceptible to changes in ground conditions resulting in joint failure, leakage or lack of gravity flow. Leak finding costs are a problem for CAR insurers due to difficulty in locating and repair. Pipes use may vary from potable or wastewater, sewerage disposal to gas, oil and product transfer or supply.

Negligence or human activity failures are not uncommonly contributing causes:

- Design – lack of foresight to accommodate potential lifespan and/or potential change
- Materials – early failure, a much shorter lifespan than envisaged
- Workmanship – effects of poor work procedures and appreciation of lifespan needs.

One important consideration for the construction risk underwriter will be how the '3C' element might be intensified by new 'global' climate change considerations. The longer the risk period the more important will climate change considerations be. Planners need

BOX 2
Rainfall and slope failure: natural and man-made situations

In the Nevada del Ruiz disaster (Colombia) 13.11.85, a relatively small eruption melted the summit icecap creating a series of devastating lahars[4] which moved quickly downhill. The town of Armero was wiped out and more than 23,500 people died. When the flows stopped the mud set like concrete. A similar effect could arise from changed rainfall patterns; increased water penetration can quickly destabilise unconsolidated slope material which has remained for long periods undisturbed. A steep slope is not essential and an initial 'creep' scenario can quickly develop into slide proportions. Ground water content can significantly intensify the results of earthquake shock, e.g. liquefaction. A move from a dry climate environment to a much wetter one has obvious risk implications.

In comparison at Aberfan (Wales) 21.10.66, following heavy rain, slope failure occurred, in this case of waste colliery spoil. Not known was that the waste had been accumulated on natural springs which added to the instability and final fatal outcome when an estimated 100,000m^3 of material moved. 145 people died of which 116 were school children.

Buildings affording facilities for a vulnerable concentration of people require particular security considerations. This may comprise a whole community or individual buildings, e.g. schools, confined entertainment or sports stadia

[4] Flow of water saturated volcanic material in the form of mudslides.

to anticipate application of "low-emission" regulations. The current uncertainty of the impact of 'zero CO_2' and 'green' issues on risk evaluation presents a challenge. The use of 'straw' or 'wood' based construction materials may be the ultimate, but insurers' potential risk exposure is rather obvious due to combustibility, load-bearing strength, effect of water saturation, etc.

The need for responsible long term environmental planning cannot be over emphasised to maintain an insurable risk potential. Environmental change can completely negate past data. Only an in-depth underwriting knowledge can provide a sound basis to make sustainable insurance decisions.

Natural drainage can be quickly compromised by creation of an impervious surface and build up of unsustainable water levels.

Key risk issues

Climate change concerns centre on increased loss occurrence frequency, severity and ultimate cost escalation. Two major risk scenarios need evaluation:

Accumulation

- The build up and concentration of risk values within a particular location or area of vulnerability, e.g. through the growth of a major conurbation on a delta

The move to a global urban dominated society becomes a prime factor when determining risk accumulation.

Aggregation

- The widespread risk exposure emanating from a prime source. The outcome may be sudden or more usually spread over a much longer period, e.G. A severe tornado outbreak, or an active hurricane season in usa;
- Series loss from repeated use of faulty design specifications, materials used or work procedures, e.G. Defective system building.

Often the potential aggregation loss can far exceed localised accumulation exposure.

To consider risk from the Construction All Risks (CAR) insurance viewpoint all aspects must be considered. Hence, social economic and political changes should not be ignored. In fact, they may have a much greater impact on the potential risk build-up than climate change itself.

One cannot give a general guide to how "3C" will operate. Change scenarios may prove difficult to forecast being:

- Immediate or very gradual.
- Unforeseen or inevitable and predictable.
- Sudden but timing undeterminable.
- Short term or permanent.

BOX 3
The Hallsands Disaster: an example of coastal '3C'

The '3C' effects of coastal works might be illustrated by the Hallsands disaster (26.1.1917). Hallsands Village is situated in South Devon. Demand for shingle aggregate providing concrete to expand Plymouth Dockyard necessitated near shoreline coastal dredging in the late 19th century resulting in shoreline beach protection dropping by 4 metres plus. The village's fate was sealed when an extreme storm struck 21 years later. All buildings were destroyed or rendered uninhabitable.

A sand/shingle shoreline in natural circumstances may fluctuate with periodic storm erosion but generally will rejuvenate to the earlier profile. With deep dredging this will not occur.

This situation might quickly arise during construction of a large port breakwater which is seriously delayed, combined with deep water access channel dredging going ahead as originally scheduled. The unsecured works will now be subject to full force of extreme storm condition. The high risk construction exposure would not arise if the dredging operations were delayed until the works were complete and at final design strength. However, significant marine downtime would be incurred, which may pressurise the project team to take a chance with the incomplete breakwater.

At first sight, climate change seems to have different horizons for each stakeholder:

- General insurers – as little as 12 months.
- Major construction risks – up to 12 years or more.
- PFI/PPP type projects – up to 25 years or more.
- Climatologists – 30, 60 or 100 years or more.
- Geoscientists – much longer.

However, what remains important are the probabilities of extreme events and how these have already changed from the historical 'norm', and will continue to do so. Each project must be considered individually as a part of overall future planning so that each is beneficial to the environment, not generating further problems. (See Box 6 on Thames Gateway).

The uncertainties in climate change for insurers are:

- Can it be identified and monitored?
- In what form might it manifest itself?
- Where might it occur?
- What would be the result?
- When? The most difficult question!
- What would be the cost for insurers – individually or in the aggregate?
  Direct loss or subsequent 'run-off' liability?

With the inclusion of large-scale manmade development (Diagrams 2 and 3) any reliable conclusion becomes further complicated. However, there is sufficient consensus of opinion and precision to make some useful predictions. The problems are how to:

- Maintain insurers' solvency during change in a rapidly expanding global environment.
- Budget costs and mitigation expenditure within social economic and political restraints.
- Determine where the 'weakest links' exist in the protective 'fence'. Can we afford the cost? Can insurers afford to continue cover at an economic level? What would have been the expenditure required to upgrade the New Orleans levee protection from the existing Force 3 hurricane resistance to withstand a Force 5 generated sea surge? New Orleans in turn is part of the Mississippi – Missouri watershed system, which faces other problems – note the mid-west summer floods 1993 estimated at the time as a 1 in 500 year event but repeated in 2008, and the predicted earthquake risk of New Madrid (Memphis) which last occurred in 1812 when the region was little developed.

An ageing infrastructure not only has the problems of the future but those inherited from its past. Renewal and upgrading is a costly but essential need if security of services and function are to be maintained (Figure 1). Patching up the past has its limits.

Realignment referred to as managed retreat from a currently untenable sea defence strategy may prove the only real economic cost option in marginal coastal areas, e.g. UK East coast, at the same time offering relief to neighbouring areas in the event of expectedly high sea surge storm conditions (Box 5).

Overseas, in many remote project areas, the difficulty is establishing the existing climatic exposures due to lack of relevant reliable data within an acceptable timeframe. For example, short duration work may miss its 'weather window' and encroach on much less favourable conditions, e.g. start of monsoon. Work may be delayed many months. Weather downtime can prove costly. Project timescales need to account for climatic variables and anticipated change scenarios, adverse or beneficial.

BOX 4
Mega-city development

Mega-cities contain more than 10 million people. Mass concentrations of people and property, with rural communities moving quickly to an urban environment, create the potential for new catastrophe hazards[5]. Development usually consists of prestige high rise central areas with lower rise surrounding suburbs. The 'heat island' effect is greatly enhanced from a rural low rise predecessor. Development tends towards coastal, estuary or river locations for ease of transport, trade and services.

These areas are prone to extreme natural hazards, in particular flood, tectonic events, ground settlement and fluctuating ground water levels. Ground mass may consist of weak fluvial deposits, unconsolidated or made-up ground. Flood protection will need to be fully maintained with periodic strengthening (Figure 4). Water level changes must be continually monitored and acted upon. Rising water levels will increase the financial burden. Many areas have developed historically from drained 'swamplands' or protected ground in-fill to support low lying facilities, e.g. shipping and airports. Greater London continues to develop downstream beyond the Thames Flood Barrier (Figures 4 and 5).

Each city development faces specific natural and '3C' risk scenarios. Mexico City in some areas has subsided by as much as nine metres due to draining of subterranean aquifers and porous soil from old lake beds now developed. The city is also sited within a major seismic zone. The earthquakes of 18 and 19.9.85 which measured 8.1 and 7.5 on the Richter Scale caused widespread damage – 5500 died as a result.

The potential mega-city catastrophe exposures have recently been shown in New Orleans (hurricane, flood), Kobe (earthquake) and New York (terrorism).

Figure 1: Demolition and renewal

New NHS Community Hospital, Essex. Demolition is high risk but essential to replace units outdated by technical change and modern requirements.

The new work has incorporated 4000 cubic metres of recycled concrete from the old hospital sites. Recycling is an important consideration avoiding landfill disposal.

BOX 6
China

Construction spearheads the massive economic development with works not only using well tried techniques but increasingly developing 'cutting edge' technology to satisfy demand. Global warming is one consideration but the '3C' environmental effects could be very important also. Project planning needs to account for potential change and consider future results. The great diversity of projects is difficult to envisage, ranging from:

- A massive power generation programme covering both coal-fired and nuclear facilities
- 50 new airports planned for the next 5 years
- Mega-city expansion but also plans to create 50 new cities by 2020 – the first to be built at the mouth of the Yangtze river (40km east of Shanghai). Many will be classified as eco-cities with population estimates between 300,000 and 500,000
- Road and rail communications including major infrastructure bridges, such as the planned sea bridge link between Hong Kong/Macao/Zhuhal (30km plus)
- Three Gorges Dam

To support the construction boom crude steel and cement production have greatly increased, the latter estimated at over one billion tons a year.

The above gives but a sample of the development taking place. Better communication and infrastructure are priorities. Global warming and natural hazards need careful consideration in planning, design and work execution. Planning the Beijing/Lhasa railway involved not only work and operations at high altitude (5072 metres above sea level) but also measures to mitigate the future potential climatic effects on large stretches of permafrost and methods to maintain a stable groundmass. This was overcome by incorporating thermosiphons to dissipate heat from the ground which could otherwise destabilise critical areas supporting rail, embankments or bridge structures.

Demolition of heritage structures is becoming a conservation issue – a common factor in rapidly expanding developing city environments.

China is no exception. Note: the massive developments in the Middle East, e.g. Saudi Arabia, Dubai, etc. The new Masdar eco-city being developed in Abu Dhabi aims to provide a zero carbon, zero waste environment.

BOX 5
Storm effects on a salt-marsh – their importance in coastal defences for East Anglia.

With a healthy salting in front of a sea wall, the cost of building and maintaining an effective defence is comparatively low. If the salt-marsh is eroded and lost, the cost dramatically increases. The marsh area dissipates storm wave action and as a substantial weight to the seaward toe of the wall, giving increased stability against water pushing against it. Complete wall failure, causing a breach in the defence line, could occur under storm conditions if the salting has been lost by erosion. In Essex alone, of the 440km of sea wall maintained by The Environment Agency, 300km rely on a salting as a 'first line' defence. If the salting were lost the additional cost for sea defences would be hundreds of millions of pounds.

[5] Only two cities exceeded 10 million population in 1950, New York and Tokyo. The 2007 figure is over twenty and rising. In 1900 10% of population lived in cities, by 2007 the figure had reached 50% (nearly 3.3 billion); projections to 2050 are 75%. New cities are continually under construction.

11.3 Social change

Social change and technological advancement are the driving forces behind '3C' change. Rapid population growth continues to transform society from predominantly rural to an urban standard, with escalating consumer demand and, hence, energy need. Demand continues to outstrip supply in both prime land and material resources, and skills. Ideally construction planning should include energy efficiency and reduced GHG emission but ultimately, cost economics become the deciding factor. However, climate policies and regulations plus resource shortages may well change the economics greatly.

The types of social change may be illustrated from:

- Small local shops to out of town hypermarkets with mass car parking facilities. These may be combined with small industrial estates built on flat marginal land with good communications access.
- Each consumer expends energy for transport against less earlier.
- Expanding holiday and global business travel requiring larger airports, extended new runways with concentrated use. Time slot landing and take-off brings delay stacking and additional energy consumption (Figure 2). Use of large land areas of flat ground becomes necessary to accommodate larger aircraft. Noise pollution should not be discounted.
- Concentrating population in cities – many vulnerable to climate change – within high-rise units against low-rise previously (Figure 3). Demand for low-rise urban residential housing support becomes a serious construction issue.
- The trend towards a 'throw away' society whereby replacement with the latest technical equivalent takes precedence over retention of an older model where repair or overhaul would be expensive or spares unavailable. Recycling is now becoming more prevalent but so also is the question of waste pollutants and ground contamination.
- Energy demand will continue to increase at an accelerating pace, e.g. cycles replaced by motor vehicles.

Developing countries have the advantage over OECD nations in that construction will utilise the latest technology, usually with less regulatory restraint and land resource restriction. However, this must be balanced against a need to comply with quality control factors. Developed nations must continually expend an increasingly significant share of their overall budget expenditure on maintenance, repair, renovation and replacement.

Social change demands better affordable housing, the latest technological consumer goods and importantly secure energy and potable water resource availability. Desalination[6] facilities become a necessity. The South East is the driest area within the UK but demands for new housing are the greatest.[7] Means of transportation will increasingly be geared to mass movement rapid transit systems – many underground in central city areas (Figure 3). Larger sea ports, airports, railways, motorways and infrastructure support must be provided to cater for high density city environments. They will need continual maintenance to cope with operational stress in a far changed situation than existed at the design stage.

Figure 2: Airport expansion La Palma, Canary Islands.

Airport upgrade – provision for expanding tourist industry with direct international flights. Note: renewable energy development runs side by side with new development.

The creation of new and upgrade of existing airport facilities encourages mass travel, particularly in relation to the leisure tourist industry. As a result, rapid local development of hotels and accommodation will ensue. New areas are being continually exploited where earlier travel restrictions are now overcome.

[6] Industrial process whereby salt water is converted to potable water for drinking and agricultural use. Increasingly long established cities will become dependent on desalinisation. This is not currently a low emission process.

[7] To meet increasing demand London has its first plant at Beckton under construction (due 2009).

Past ground engineering could not have foreseen today's environment. However, many works built in Victorian times have proved very resilient to change – others have failed the test of time or are under extreme '3C' stress.[8] Future failure is a definite possibility. With limited funds available and a tendency to delay the potential catastrophic protection, disasters will occur. The questions are, when and where? Who can say where the latent defects lie? The New Orleans Katrina and Rita hurricane losses in climatological terms were far from being extreme events – near misses in many ways. The fundamental problems of low lying river estuaries apply to many similar areas. This may be particularly acute where downstream of a major watershed catchment area, e.g. USA mid-West or many parts of Asia. Common problems arise from subsidence, usually the result of land drainage[9] or coastal erosion, e.g. in relation to a delta dependent on sediment deposition.

Social change in underdeveloped areas will create a much stronger awareness of the benefits of risk sharing by way of insurance. Many disasters highlight the significant levels of uninsured loss and dependence on government, state or aid support. It takes time to recover and involves major costly construction programmes. The important fact is that the costs of a natural catastrophe may be insurable and hence funds made available for the reconstruction work.

Figure 3: Inner city development

Broadgate, City of London – incorporating Liverpool Street Station/Great Eastern Hotel. City expansion creates continual change. Only a small fragment of Old London (low elevation) survives surrounded by new multi-storey office blocks and reconstructed railway and hotel complexes. The demand for high-rise structures continues apace.

Liverpool Street was built in 1829, the railway terminus opened in 1874 and Great Eastern Hotel in 1884. The older Broad Street station opened in 1865 is now replaced by the new Broadgate complex.

Liverpool Street station is an essential part of the underground rail network.

11.4 Construction

Construction work generally can be divided into three main categories:

- Civil Engineering – will include infrastructure surface and sub-surface works to offset the effects of climate change, e.g. sea defences, drainage.
- Building – will reflect the need to be resource-efficient, e.g. zero energy, zero waste, and also resilient to climate damage.
- Mechanical, Electrical and Process Engineering – will seek to provide more efficiency and reduction in GHG emissions.

Most projects will include all, to varying degrees. Underwriting may be influenced by the predominant category. Two important aspects arise:

- Impact management.
- Emissions control.

Climate change will often affect the event frequency and severity of natural events. Natural risks either involve:

- Atmospherics, meteorology – which will include wind and storm (in their many forms and terminology) rain, hail, snow, ice, etc., influenced by temperature variation; or
- Geology, hydrology – which includes earthquake, volcanism, lahars, and tsunamis. Such ground- or water-influenced events may be substantially modified by changes in climatic conditions.

It is useful to consider wind/precipitation exposures as against those applicable to ground/water engineering. As with climate change, differences may prove either macro- (of global consequence) or micro- (of very localised application – see Box 1). Temperature and precipitation are key factors (Box 8).

[8] London's existing wastewater, sewerage system is undergoing a major upgrade.

[9] Draining land will cause natural subsidence to a varying degree. UK coastal areas earlier impounded for agricultural use are particularly vulnerable to sea level rise, e.g. the Fens/Wash area.

Examples of weather climatic high risk construction exposures might include:

- Projects exposed to open sea, coastal or estuary storms, tidal, surge, etc (Figures 5 and 6).
- Cofferdams providing secure 'dry' work conditions. Overtopping may occur in very severe conditions (Figure 9). Where insurers consider the risk inevitable, cover will be withheld against its occurrence.
- Tandem crane lifts or use of helicopters in congested or remote worksites.
- Temporary works structurally unstable or lacking rigidity until completed. Guy support may be stipulated as an insurance condition.
- Surrounding or adjacent property dependent on full maintenance of existing support during progress of site operations. The main risks are collapse or subsidence (Figure 7). In the UK special provision is provided under the current JCT SBC Form Clause 6.5.1.
- The effects of climate change may be illustrated by de-watering operations, a necessity where coastal, riverside work is undertaken or a variable high water table exists. If critical, local water levels are not maintained, serious failure may result to third party surrounding property, perhaps extending over a wide area.
- Flash flooding potential where work is in, on, or over water. Dams present the obvious case as during work progress water diversion must prove adequate to accommodate not just normal calculated flows but potential flood excesses. Careful analysis of river flow data is an essential determining factor. Overtopping and consequent erosion may or may not prove inevitable. Clearance of accumulated debris, de-watering and other cleaning up operations can present a substantial insured loss. Water flow predictions can quickly change (Figure 9).
- In many remote locations the problem is not the extent to which climate change might affect the site risk exposures but the scant reliable information to formulate a true exposure guide.
- Large river systems may not be controlled by a single authority with a common political interest. Control of water resources is becoming a major political problem where dependence is vital.

In areas subject to seismic disturbance earthquake building design will provide protection against the main effects according to stipulated potential scale intensity. However, the most vulnerable locations are not static and will change – the most important consideration relates to the area geology and the effects of tectonic shock movement. Foundations based on made up ground infill or estuarial silt type deposits will be subject to liquefaction. Ground conditions can be far from consistent and vary significantly within a short distance. This equally applies to any variable condition, not the least climate change potential during the planned project lifespan. Climate change can greatly alter groundmass conditions and the effects of tectonic shock. The effects on water saturated ground will differ considerably from a rock hard dry condition. Liquefaction and lahar development can have catastrophic results (Box 2). Similarly, potential hurricane or typhoon intensity will determine design standards and will be influenced by revised climatic intensity considerations.

Short period weather forecasting, usually regarded in the UK as not exceeding four days, becomes of vital necessity combined with expected seasonal weather variation. Original construction works planning should account for anticipated weather but based on historical records these may be found wanting in the field (Figure 9).

Storm 'tracks' are difficult to determine with landfall the major threat – a combination of sea surge and wind force damage potential. Whilst design planning will be for the

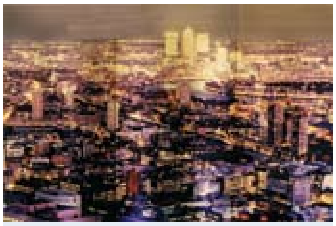


Figure 4:
The expanding city: View from 30 St Mary Axe looking towards London Docklands.

The London 'Heat Island' now extends far downstream from the old city boundaries. Development will continue apace into the foreseeable future. Newly created city complexes now abound in the developing economic territories.

London has extended post WW2 far beyond its earlier limits converting old dock areas to an equivalent city downstream served by a new airport and newly built rail system. That expansion is no different than many other city complexes overseas. Expansion usually entails development of marginal ground in vulnerable low lying coastal or river estuaries.

long-term, specific construction work in progressive phases will face its own short-term climatic decisions. These considerations, which may involve high risk operations, are far different from the long-term ones.

Site choice for off-sites, campsite, storage and access routes needs careful appraisal. A dry desert wadi may transform very quickly into a raging torrent through flash flooding. Although occurring perhaps only once every ten or more years it remains an essential risk consideration.

Figure 5: Thames flood barrier. View upstream – London/Docklands/ Millennium Dome/ 2012 Olympic sites.

The major protection of the City and London Docklands development. The planned lifespan of the Barrier is now anticipated to be much shorter than expected due to Climate Change.

Potential flood exposures are of major concern and need be kept under constant review with periodic upgrading works. A fine balance needs be maintained between excess outflow and extreme storm-tidal sea surge. Major expansion projects include:

City and Docklands High Rise Development

Thames Gateway Expansion

Rapid Transit systems – Crossrail, Eurostar

Olympic Games facilities

11.5 Planning

From the basic concept, detailed plans evolve. Climate change and its anticipated short and longer lifespan term effects must now feature prominently in project assessments. Impact planning requires professional guidelines as a decision tool. Long-term durability should not be sacrificed for short-term economic cost savings with reduced resistance to deterioration and weathering. Costly maintenance, retrofitting and renewal must be avoided. Development may suffer where design may be compromised leading to rapid deterioration over a relatively short period. Climate variables can noticeably influence the outcome.

Long-term weather considerations are fundamental in planning design and development for the Construction Industry. Climate change variations should be built into project planning to ensure –

- Good, sound, flexible design.
- Use of best compatible materials.
- Acceptable erection methods and procedures.

Project planning must evaluate long-term climate change within the expected period of use. Maintenance cost and upgrading need to be inbuilt with flexibility for future adaptation. Successful works may well outlast their original planned use notwithstanding modern pressures, due to “over-design” in advance of current requirements, e.g. Sydney Harbour Bridge after its opening Australia (1932)[10]. Others will not last the term due in the extreme case to structural failure, e.g. Tacoma Narrows Bridge failure USA (1940)[11] or more likely the need for continual expensive renovation involving unbudgeted costs. Over-design has the advantage of protecting against future climate change not envisaged at the time work was accomplished.

The detailed planning stage including preliminaries up to contract award is the most important. Once the construction contract is agreed, subsequent amendment probably becomes a costly contract variation order. Insurers’ views need to be voiced within this pre-contract period. Simple protective measures from the outset that reduce risk include features to benefit the eventual owner’s long-term interests, e.g. protection of exposed ‘floodplain’[12] sites or perimeter ‘saddle dams’ to retain impounded reservoir waters should they rise above certain defined water levels[13] .

Architects, consulting engineers and others concerned with the planning process will need consider their professional duty to evaluate client responsibilities and options relative to climate change. Decisions will rest with their principal to incorporate recommendations made. Plans need to incorporate requirements as to energy use and acceptable GHG emission levels combined with the use of energy efficient materials. Cost incentives may apply.

[10] Solid sandstone foundation. Original capacity estimated at 6,000 vehicles per hour plus trains and pedestrians. The annual average daily traffic grew (from 11,000 in 1932) to reach 181,000 in 1987 prior to completion of the Sydney Harbour Relief Tunnel.

[11] Designed to be flexible but was aerodynamically unstable. Destroyed 4 months after handover by gusting wind of less than 45 mph. This arose from the failure to consider resonant frequency and damping.

[12] Relatively flat ground bordering a natural river or watercourse subject to periodic exposure to water inundation. Ground usually consists of alluvial soil or sedimentary material overlying base rock strata.

[13] Approximately 8% of the land area in England is at risk from river flooding and a further 1.5% from direct flooding from the sea.

Rules and regulations are continually changing and need to be carefully considered when drawing up contract schedules allowing flexibility in the event of subsequent alteration to conform to anticipated UK government or EU Commission edicts. New regulations normally allow for a time lag in planning but timespans for the large project need to be borne in mind.

Energy performance and emissions from buildings becomes an important consideration providing the impetus behind the 2002 EPBD focusing on carbon emissions. In England and Wales, 27 % of these come from residential buildings. Art.7 lays down the need to produce EPC at point of sale or rent but importantly upon the completion of new buildings. Planners need to keep fully aware of potential change and compliance requirements. Two points arise – incorporation in the original planning and implications on lifespan risk.

Planning requires consensus on climate change and 'green' issues. Whether the assessment proves correct is the risk factor. Locations only a short distance apart may experience quite different effects from the same event, e.g. storm-flood scenario.

BOX 7
Thames Gateway development[14]

The Thames Gateway development is the largest regeneration programme in Europe covering some 40 miles from the City perimeter to Southend (Essex) and Sittingbourne (Kent). The cumulative flood risk potential is well set to increase over the next century due to changes in climate prediction, sea level rise and social economic population stress.

The Environment Agency has direct responsibility for construction, upgrading and maintenance of flood defences, e.g. the Thames Barrier (Fig. 5) providing high level protection against both river discharge and tidal events. Sustainable construction development will increasingly require consideration of new defence strategies in particular to prevent a recurrence of the 1953 North Sea flooding disaster.

TE2100 – Thames Waterway Plan – are high profile projects aimed at protecting vital assets within the tidal area – Essex (Northern) Kent (Southern) estuary linking London to the North Sea through to Teddington Weir, the tidal limit.

Climate change considerations must account for extremes:

- Intensified and more frequent storm tidal sea surge.
- Increasing sea level rise due to 'global warming' and isostatic subsidence. Areas below the 5 metre contour are increasingly at risk with an estimated sea level rise to 2080 of between 26 and 86 cm with extremes up to 2 m.
- Higher river outflow events following prolonged heavy rainfall and upstream land use.

Whilst the Thames Barrier is considered 'fit for purpose' to 2030 to withstand an estimated 1:1000 year event it is necessary to fully research future needs within a major flood management risk programme as the safety margin after 2030 decreases steadily. Currently over one sixth of London's inhabitants are at risk from flooding.

The cost to upgrade flood defences to predicted 2100 requirements based on current prices is estimated at £4 billion (to protect existing insurable assets of £80 billion) of which £200 million in the next 15 years. The strategy includes managed retreat on the Essex coastline (see Box 4). The Wallasea Island Wild Wetland Coast project (700 hectares) is one proposed scheme where long-term future farming cannot be assured due to sea level rise. This trend is likely to continue due to erosion on UK's vulnerable East Coast.

Thames Gateway regeneration development envisages some 120,000 new homes where location and environmental design must fully account for potential flood risk together with essential protective infrastructure. Note 90% of the land targeted for development lies in the floodplain (Stern 2006).Removal of waste sewerage and effluent is a major stress concern adding to the continual need to upgrade to accommodate population and use growth.

London's main infrastructure support remains underground so is vulnerable to any flooding, as well as facing the effects of a potentially rising water table. Can existing design criteria cope with this?

The ODA for the 2012 Olympics have set limits where possible to encourage use of renewable energy reduction in CO_2 emissions, reuse or recycling of demolition waste including offsite aggregate supply and importantly to minimise transport to site by maximum use of rail or waterway links.

BOT/PFI/PPP type projects are in vogue with risk protection of particular relevance bearing in mind the continuing maintenance exposures for usually 20 to 25 years from works' practical completion date. Climatic change considerations, adaptable to accommodate future risk reassessments, must be envisaged in drawing up initial planning. Current safety margins in a project specification may need to be strengthened.

[14] 150 years ago downstream from the City, areas now fully developed were classified as 'marshes' – Ordnance Survey Sheet 72 – 1844; a not uncommon feature today of many cities worldwide.

Government and local authority ownership controls are now tending to pass to private investment regeneration, forming an important equity participation source for the residential build sector. Infrastructure, power generation, quasi-government departments, i.e. NHS, Prison Service, Military, now comprise a major private commercial investment area by reason of participation in PFI/PPP and similar projects. The BOT form of contract applies equally to many overseas works.

Much greater responsibility will fall on the professions. Assumptions made in drawing up a potential project hazard profile need to be monitored to ensure compliance of essential protective measures, e.g. reliance perhaps on third party authorities? A large housing floodplain development may be entirely risk dependent on provision of funding for a major flood defence scheme and its implementation and upgrading within a given time frame.

Essential in planning is the infrastructure support requirement, e.g. roads, rail, utilities and services supply, administration. Often the logistics system proves a major climate hazard. Construction work in remote areas requires temporary access roads and facilities not designed for permanent use once the project is achieved (Figure 9).

Overland supply of pipes and materials for a large pipe laying project may involve long distances, very remote areas subject to very varied climatic conditions with rapid weather variation – or, congested built-up or industrial areas and work within a confined weather prone workplace.

Situations where the infrastructure has been given priority, e.g. flood defence scheme, has an advantage over earlier developments where necessary infrastructure was lacking, or required continual updating due to unanticipated growth. Major cities continue to expand globally requiring extensive support services and infrastructure (Figure 4). Note the current London Thames Gateway and Waterway projects with flood prevention measures for the 'Brownfield Reach' area downstream from the Thames Barrier (Figure 5), and the 2012 Olympic Development. The Essex coast and Thames estuary are of particular concern (Box 4). Many large cities, e.g. New Orleans, share London's challenges, with local variations, from the oncoming effects of climate and environmental change. Updating existing facilities may take up a significant and increasing share of available funding. '3C' environmental change must be fully accounted for in the planning process.

Advice from an environmental perspective is now considered vital for many projects with geo-scientific recommendations sought from the responsible Environment Agency or Flood Executive, e.g. EC Floods Directive Working Group. Climate change and its long term "lifespan" effects will increasingly become an essential factor for consideration. Natural variability is a factor that is often underestimated. However, planning cannot be expected to accommodate every conceivable hazard situation.

The contract stage

Investors in a project generally require acceptable insurance protection being in place at the pre-tender stage. Typically this may be provided by the JCT 2005 Major Projects form or other contract forms usually amended from standard publications which may give the same effect. Overseas aid projects tend to favour the FIDIC form approach.

Once the contract has been awarded, insurers' involvement is determined and the risk profile set. Close liaison between the parties now becomes paramount, insurers and usually skilled intermediaries acting as members within the group project risk management team.

Three distinct phases apply:

Pre-contract	• Concept feasibility • Outline planning and design • Regulatory, local enquiry, e.g. conservation • Detailed planning, outline costing, budget • Contract form, pre-tender negotiation • Tender approval
Contract	• Award • Terms agreed • Works progress • Provisional acceptance – handover
Post-contract	• Contractual maintenance • Latent defects • Guarantees • Lifespan utility and operation

The insurance programme needs to be in place at the tender-seeking/financial-funding stage to protect all stakeholder interests.

Strict contract pre-qualification procedures should be adopted to ensure only those suitably experienced apply. Liability arising from inherently defective work may continue long after final handover certificates are issued. Climatic problems may be slow to develop.

'Force Majeure' becomes an important risk consideration. Under contract, risks falling within this category (usually defined) will be the responsibility of the Employer. Examples may be unforeseen ground conditions, e.g. tunnelling, or storm conditions in excess of a stipulated intensity level.

Construction insurance cover is generally limited to physical loss or damage to the insured work and separately liability risks arising. Protection against abandonment, failure of the project objectives, efficacy or output deficiency is not provided. A very limited market may be available to insure specific performance risks. Increased costs of working are excluded, e.g. ground conditions proving different from those envisaged.

Figure 6: Infrastructure planning new dual cable-stayed crossing, River Neva, St Petersburg, Russia.

Infrastructure planning must account for staged handover usage in addition to variable extreme climate events when weather vulnerability may be high and final design criteria not yet achieved. Plant and equipment, particularly craneage, are particularly at risk.

St Petersburg faces a similar threat from rising sea levels as London (Stern 2006).

One motorway crossing operational whilst work on second in progress. Similar to the QEII Dartford Crossing (London M25 Orbital) interchange to divert heavy traffic from congested city areas.

Work period limited by severe winter weather. At other global locations weather conditions to be considered may include typhoon, hurricane or monsoon periods.

11.6 Risk management

Risk management must identify all areas of potential hazard exposure (Diagrams 2 and 3). Action to mitigate potential works loss or damage will include insurance obligatory in most cases by reason of statute or contractual commitment.

Construction insurers are not faced with short term risk easily adjusted to cater for an adverse trend, but with increasingly much longer periods. Project values are increasingly concentrated into high profile long term environmental risk exposures. Major construction engineering works, from original conception to practical completion, now extend easily to ten years plus, followed by up to a further twelve years 'latent defects' liability. Where the construction contract is under seal, course of action for breach will accrue for 12 years from practical or substantial completion.

Risk management requires a sound working knowledge and experience of the inherent risks in the proposed work and potential disaster outcome should failure occur. This places a need for sound technical knowledge on those charged with professional responsibility, not least the insurers. As a result, the 'lead' insurance market has become limited for the major projects as have those intermediaries able to control an integrated security risk programme.

Insurance represents only a part of the overall risk exposures. Some causes may be uninsurable, e.g. strikes – others, whilst insurable, may prove uneconomic from a purchaser's cost viewpoint. Where delay is a direct consequence of loss or damage by an insured peril, insurance in the form of Advanced loss of Profits, Delay in Start-up or cover for expediting expenses may be available.

'Trade risks', e.g. policy deductibles, cover limitations and exclusions, must be borne by those responsible (usually stipulated in a written contract) as must perils for which insurance is not obtainable. Climate change can make a high but acceptable risk, uninsurable.

A project critical path work analysis must recognise the anticipated indeterminate nature and variances in weather and climate with requirement for incorporation of acceptable flexibility to achieve planned completion (Figure 6).

JCT contracts have for many years stipulated in great detail the scope of responsibility of each contracting party and the extent of insurance required to comply. This had become unduly complicated hence in 2005 a new simplified approach was adopted. Of particular interest were the Major Project conditions which not only simplified the indemnity clause but opened the way for a tailor-made project insurance programme extending, if the parties agreed, for up to twelve years following project practical completion. Cover would not only embrace the traditional Contract Works material damage and liability covers but also acknowledge the importance of professional indemnity protection and provision of latent defects coverage. Bearing in mind the equity investment attraction of PFI/PPP deals, this additional feature adds valuable security protection by way of insurance.

11.7 Existing infrastructure

Climate and location have always determined earlier construction design, form, methods, materials and eventual lifespan. Technical development and well-enforced regulatory compliance mean that obsolescence increasingly applies to old-build, so there is a real need to continually update to remain competitive with new-build. However, a point is reached when the construction's durability expires and retro-fitting is no longer an option (see Figure 1 for example). New climatic considerations and requirements may mean structures are no longer either technically or socially acceptable. A modernising world wants the latest improved living and work standards, e.g. temperature controls – heating or air conditioning. These demands may run contrary to efforts seeking to reduce energy emissions.

Protection against increasing potential major natural risk exposures remains an expensive consideration to safeguard increasingly vulnerable property and assets.

In emerging nations, progress remains largely dependent on affordability and utility. Increasing wealth brings consumer demand and consequent sophistication. Currently newly developed areas have the great advantage of being able to capitalise immediately on the latest available technical knowledge and expertise. Eventually, renewal will become the same problem there as for developed societies (Box 6).

Maintaining existing infrastructure, buildings and machinery to modern standards and capability is necessary but very costly. This means that many "permanent" buildings are now replaced well within 60 years. Climate change will accelerate obsolescence. Their decommissioning and demolition presents particular risk exposures. There are many considerations, e.g.

- Nuclear power facilities – many are sited at vulnerable coastal locations.
- Conventional power stations or other facilities which used asbestos as fire insulation.
- Brown versus green field. Previous use raises problems from earlier site operations in the 'brown field' site category, e.g. pollutants. Sites may involve costly clean-up expenses for regeneration development. 'Green field' developments raise conservation issues.
- Upgrade costs can exceed new-build, but the need to continue essential services may dictate retrofitting, with ever accelerating maintenance costs.
- Low priority for maintenance due to limited financial budgets.
- Latent defect problems. Projects not built for longer term or to current building standards.
- Current regulatory standards compliance. This creates a particular strain on retention of outdated units, e.g. accommodation units for the aged. Climate change will generally add to the economic costs, particularly the continued use of outdated building structures.
- Demolition work is potentially a high risk construction operation (Figure 1).
- Heritage preservation issues (Figure 7). Heritage buildings give a clear example of past climatic weathering and change. Gradual effects such as dampness, water penetration, high humidity and condensation, may all be present.

Figure 7: Heritage retention

Funchal, Madiera. Retention of existing structures presents specific site problems. Removal of ground support relies greatly on sound rock foundation and favourably dry climate.

Ground conditions are not always as favourable. Prime considerations are the unknown factor – deterioration, the effects of ageing and dependence on past construction technology. Foundations commonly bear little comparison with today's basic requirements.

11.8 Design

No two projects should be considered the same. Small variations can expose 'high risk' insurance considerations. Analysis of climate change risk needs to include three phases:

- At the planning stage.
- During work progress.
- Afterwards for lifespan utility.

Design will be increasingly influenced by energy saving, and the need to reduce GHG emissions, within acceptable cost parameters; likewise the use of materials and equipment to be installed. This will be reflected in form and layout (Fig.8).

Advanced energy efficient technologies do exist but generally remain under-researched or uncompetitive, compared with the cost of current conventional standards. New technologies generally meet a cautious insurance approach where design risks for prototypes or use of new 'untried' technology may be excluded from a CAR policy or cover restricted in some way. Although, generally, cost may be a guiding factor, climate change must not be ignored, because of the probability that climate impacts and emissions regulations will become more significant during the lifespan of infrastructure and buildings (Fig. 8). What construction materials are most CO_2 emission free taking account of production, manufacture, construction and lifespan usage and disposal? Lifespan usage figures covering a 60 year period may well yield far different results to those applicable up to contract works completion and rating at the point of handover to the owner. This is an area of considerable uncertainty, where new findings might result in changes in design specifications.

Project design is a key CAR policy risk where cover is usually provided but with limitations, e.g. exclusion of –

- Betterment or re-design costs.
- Replacement or rectification where no physical loss or damage has occurred.
- Replacement of the faulty part. Access costs – inevitable damage to sound works to enable rectification may be qualified.
- Guarantees as to performance or output.
- Undamaged but defective contract works. Physical loss or damage to insured work may disclose latent defects in other undamaged work requiring immediate rectification to avoid a similar occurrence.

Separate professional indemnity supplementary cover may now be contractually required, e.g. JCT /SBC 2005 Clause 6.11 CPD. CAR insurance, at best, may only provide a very limited cover for architects, consulting engineers, etc., e.g. site risks only.

Foundation design requirements for pre-WW2 buildings may not bear comparison with those of modern specifications – clearly shown when subsidence occurs. The inclusion of flood, subsidence and heave risks did not happen until the 1970s within standard UK householders' comprehensive policies and more recently within an industrial 'All Risks' format. These risks have formed an important component of the standard CAR policy. As a result, property insurance loss experience covers a limited climatic period. Certain ground conditions and risk locations receive special consideration, e.g. clay soil, floodplain or coastal exposures.

Figure 8:
High rise design
30 St. Mary Axe, London – Model – 40 storeys.

Completed in 2003, the result of rigorous virtual prototype computer design simulation testing for wind resistance under all anticipated weather conditions combined with lightweight strength based on a central core.

An 'iconic' structure, the forerunner of several planned city high-rise buildings. Note the extensive use of glass against the more traditional masonry structure. Energy conservation to maintain minimum emissions levels becomes of prime importance in providing a more efficient working environment.

Controlled air flow cuts heating and cooling costs significantly. The use of natural light is enhanced.

The latest planned skyline project 'The Shard of Glass' will be London's tallest at 72 storeys – 310m high.

Does design include procedures to achieve the final contract works, e.g. essential temporary or offsite operations? What provision has been incorporated for potential environmental change? The risks during work-in-progress may be far different from those of the final structure. Weather risks feature highly in any construction risk analysis and assessment conclusions. The design of site temporary works should account for short term risk exposures and specific location needs.

Essentially, changes in design or materials used should be kept to a minimum once work has begun due to the delay disruption factor and effect this can have on cost escalation.

In the event of insured loss, new regulatory requirements may be enforced, applicable not only to the reinstatement of damage but also to undamaged sections. Cover is required.

Ground-works, generally extensive for civil engineering projects, will need to assess the effects of past climatic change. The environments which created the various strata may have been very different from those existing today and the ground strengths and weaknesses not fully understood.

Tunnelling work involves the creation of a supported space or void within a ground mass which, prior to excavation, was in local equilibrium. If pressures are not effectively checked, collapse, distortion or heave will result. Exposure to air or water will initiate chemical and other weathering processes. Changes in surface environmental conditions, weather related or otherwise, may rapidly permeate sub-surface structures and quickly destabilise the surrounding groundmass. Landslip and landslide conditions can develop with underground construction working quickly inundated.

Sudden potential failure can equally relate to volcanic areas of unconsolidated porous deposits [sometimes of ancient origin] (Box 2). Once the critical water content level is exceeded, gravitational movement can create an unstoppable land-slide (Box 8).

Glacial retreat and permafrost melt also put pressure on facilities and installations as to whether design criteria when constructed have sufficient inbuilt flexibility to adapt to new conditions (see Box 6 – Beijing/Lhasa railway).

The geology of many sites is highly complex, particularly at tectonic plate margins with areas of unstable rock formation, e.g. subject to avalanche, lahar, mudslides, etc. These need to be constantly monitored.

Safe working period 'windows' in alpine areas are governed by potential avalanche and severe winter weather considerations. Mild, warm conditions may quickly destabilise areas earlier considered reasonably safe. Earthquake shock can trigger an avalanche scenario over a very wide area. Another case for concern is the thawing out of permafrost in Arctic regions, leading to unstable ground conditions for infrastructure like roads, railways and pipelines. Areas subject to monsoon rains with consequent flooding face seasonally increased risk exposures, but monsoon intensity areas affected and exact timing may not be predictable. An unexpected monsoon hit the Arabian Gulf in 1975 seriously affecting many new sites.

The effects of storms on coastal defences are well illustrated along the East Anglia/Essex coastline. The rate of salt-marsh erosion exceeds 2% per year (Box 5). Other coastal areas may differ in detail, but the principles hold good.

To what extent have off-site risks and access to site risks been evaluated? Climatic considerations are easily overlooked, e.g. flood, landslip, inclement weather, etc. In remote areas access may present high risk insurance exposures.

BOX 8
The Vajont Dam disaster

The classic '3C' construction case is probably the Vajont slide in the Italian Alps which occurred on 9th October 1963, and illustrates several points. A major slope collapse occurred falling into the newly impounded reservoir creating a catastrophic downstream flood. The newly built dam survived without damage. Heavy rainfall had saturated clay overlain with limestone dipping each side towards the reservoir valley.

The existence of ground conditions prone to landslip needs careful consideration. Clay type ground or unconsolidated materials are susceptible to movement when excessive volumes of water are introduced, particularly in areas affected by seismic shock. The sudden rise in water level and subsequent efforts to mitigate its effects must have greatly influenced the outcome – an estimated 1900 people died. A local "climate change" can upset the local equilibrium causing catastrophic results.

Design should take account of anticipated change and stipulate added requirements necessary to safeguard potential exposures, e.g.

- Floodplain site – protective measures need be in place to overcome a threat from surface inundation or rising water table, e.g. creating a negative drainage scenario and backing up of wastewater, sewerage.
- Housing in areas of protected trees or woodland – foundations must be designed to withstand potential subsidence or heave risks, a particular problem in clay type soil.

11.9 Materials

The extreme diversity of materials used requires analysis for both suitability and performance to achieve the planned outcome. Materials suitable for one site may not necessarily be suited to another although a similar construction works plan may have applied.

Cost-conscious construction engenders innovative design incorporating cost effective use of suitable 'on site' building materials. Climate change is a major consideration entailing inbuilt flexibility for the anticipated lifespan. Temperature and water related tolerances are important in relation to strength, weight and durability (Box 9).

Location is the prime consideration, together with application of changing local geological and atmospheric conditions. Such arise when considering differing environments:

- Coastal – corrosive saline atmospheric sea exposure, humidity and exposed storm position.
- Desert – extremes of heat and dust exposure. Note: night-time temperatures may fall to 0^{o}C or below.
- Alpine – permafrost, melt, freezing, blizzard and avalanche.

Traditional materials in common use are very adaptable, wood, stone in its various forms, e.g. slate and bricks with special types for varying uses. Weathering, however, remains an important issue. Some varieties are more resilient than others dependent on climatic exposures. Excessive temperature or precipitation variation can have a marked deterioration effect. Engineering bricks will be needed where unit strength and durability are needed.

Modern synthetic materials may have limited resilience to weather exposure and prove susceptible to unforeseen deterioration. Testing trials carried out may be limited in time and location resulting in unexpected exposure to unfamiliar climatic conditions.

Wood substitutes in forms such as chipboard used for internal panelling or weather-proofed roofing material are not resilient to water penetration arising from, e.g. storm or flood.

Consistency and compatibility can relate to the most fundamental materials. Concrete – a mix basically of sand, course aggregate, cement and water – must be suitable for the job in hand. 'Lean' mix for a car parking facility is very different from foundations for a major construction, e.g. coastal nuclear power station or motorway river crossing support (Figure 6).

Cement production releases huge amounts of CO_2 during its process. One tonne of cement equates with roughly one tonne of CO_2 taking account of site, transport and storage. Research into a 'green' alternative based product reducing CO_2 output is interesting.

Compatibility extends not only to a product, e.g. concrete, but equally to its ingredient materials in close chemical contact. A common example is iron or steel reinforcement within a concrete form. Iron staining is a common sight – the first sign of potential problems caused by small cracks enabling moisture to infiltrate. This may arise from a 'heavy dew' humidity effect and not essentially heavy rainfall. Apart from chemical action, freezing will add to the problem with concrete surface deterioration and sections breaking free – a potential liability exposure. The cracking may indicate the early signs of serious failure although damage may, at least short term, be confined to the outer surface and overall strength unaffected, similar to natural rock weathering. The use of locally quarried aggregate may prove unsuitable and chemically reactive causing early deterioration. Poor standards of supervision or workmanship are common causes.

Materials must not only prove compatible in their make up but be compatible with the environment in which they are used. A saline environment, such as prevails in many Middle East Gulf sites, must be assessed. Reinforced concrete to normal UK housing standards may, in this environment, have a very short lifespan, especially if locally sourced materials were used without careful analysis. Lessons were learnt from the Middle East construction boom of the 1970-80s where locally obtained sand and aggregate were used with disastrous results. Road surfaces, rail tracks and bridges may all become over-stressed in heat wave temperatures with resulting melt, buckling or failure due to lack of adequate expansion joints.

Performance and durability may well depend on previously established but out-dated criteria with materials used beyond designed climatic tolerance. This may result in damage to the component part or, in the extreme case, endanger the entire construction by its rapid depreciation.

In the UK , within a heavy clay ground area, different considerations apply, particularly where combined with a fluctuating water table level or mature tree growth. Care in selection of foundation material, e.g. resistant reinforced concrete may be needed to counter potential settlement or degrees of sulphate attack within a clay type environment from clayey sand beds to wet gypsum rich London clay.

Materials designed for one climate or environmental expectation may not perform satisfactorily in a changed environment. Many items are imported from areas not fully conversant with UK weather patterns notwithstanding regulatory compliance. This may equally apply where UK products are exported overseas. The effects of a change in climate arise immediately. The failure of volume materials or component parts can lead to a significant series loss accumulation for insurers.

Water is another "material" consideration. Saline intrusion into the works water source causes problems, not to mention the presence of other unforeseen impurities or external pollution, e.g. mercury, when water containing trace amounts is used for testing purposes. Naturally occurring pollutants, e.g. arsenic, must not be overlooked.

BOX 9
Temperature and water

Climate change may result in hotter, colder, wetter or drier climatic conditions and naturally affect the hydrological cycle. This will likely impose conditions far different from those envisaged at the planning stage. Introduction or extraction of groundwater, whilst gradual, may culminate in a sudden extreme outcome, e.g. saline water intrusion near coasts.

Progressive ground settlement is a persistent problem in built up areas constructed on an unconsolidated or porous groundmass. The presence or absence of water is a key factor. Drainage will naturally cause settlement as seen in many mega-cities.

Temperature will determine water form and hence likely effect. Many variations occur:

vapour, steam, humidity, moisture, condensation, dew, mist, fog, rain, hail, sleet, snow, ice.

Water may be 'hard' having a strong mineral content or 'soft' with only a trace element. The pH rating is important determining acidity or alkaline content. Rain is slightly acid pH 5.4 against a neutral 7. A change in rainfall frequency or pH rating can result differently in varying environmental situations. Geological features are a prime consideration. The effects of acid rain may aggravate weathering. The use of mineralised water for agriculture can have a degradation effect resulting in early need for fertiliser use. 'Limescale' deposits are a problem in heating installations.

Individual occurrences may aggregate overall to a significant comparable event. There may be little difference between the losses from a regional housing development from flood than the same number of units developing a common fault, e.g. a defective roof membrane due to unforeseen weather conditions – each needing urgent replacement to overcome potential or actual water damage

Unplanned change may easily occur during works progress without timely observation, e.g. effects of prolonged storage in extreme unforeseen climatic conditions.

New materials are not without their disadvantages, not always appreciated when fitted and hence insurers need to scrutinise the product tested performance profile. Reliance on the producers' performance manual may fail to highlight matters relevant to insurance risk.

- **Fire** – Their heat-resistant qualities encouraged the wide use of asbestos based products. The major insurance crisis and subsequent problems for demolition or decommissioning will remain for years to come. Foam insulation panels might pose a pollution threat to the local water table if not securely handled for disposal as against earlier landfill dumping. Toxic dust becomes a major concern with strict legislative controls now in force. High resistance may still have disadvantages and eventuate in an explosive flashpoint when toleration temperatures are exceeded. Products considered 'green' e.g."zero-carbon" materials, may be limited in their application and purpose, or carry unforeseen risks. Thorough testing should be carried out where appropriate.

- **Heat** – Higher and, perhaps more important, wider daytime temperature differentials need to be carefully assessed, with suitable allowances for joints and clearance tolerance levels. Increasing climate change extremes may exceed designed allowance. Colour is a key factor – white preferred
- **Strength** – Design structural loading including allowance for both compression and tension must be met, allowing for, in the case of heat expansion/contraction, the potential failure or longer-term weakening or weathering effect. Under some conditions materials may alter their physical properties. The later deterioration of concrete using HAC in the 1970s led to its prohibition and withdrawal of cover by insurers.
- **Durability** during the construction's planned lifespan will be important from a maintenance or renewal perspective. Some components are anticipated renewables if only due to 'fashion'. Some components tend to suffer loss of rigid strength over time. Materials well tested in one environment may prove totally unsuitable in another and, in a climate different from that originally designed and tested for, could fail in performance. An overall change in temperature extremes can only widen the exposure potential (Box 8). Traditional materials have a long historical use record. New products may rely on limited trials and scientific assessment. Long-term 'field' study and exposure is not generally an option. How will the new product material stand up to the extremes of climate change?
- **Lightweight roof construction** popular with system building and low cost 'affordable' construction may fail due to storm stress, etc. Flat roof construction will generally attract restricted acceptance terms when seeking Latent Defects protection, e.g. cover subject to periodic review at, say, 2 and 5 years from construction practical completion date. Precipitation may cause problems due to failure of the roof weatherproofing. Metal and asphalt membranes may prove 'unfit for purpose' bearing in mind the possibilities of sustained heavy rainfall, hail and snow/ice loading.
- **Unforeseen latent deterioration and loss of functional use** is a general concern. Latent defects insurance is generally restricted to collapse risks usually extended to cover subsidence, heave and failure of the waterproofing 'umbrella'.
- **Suitability and availability** – essential materials may quickly become scarce or expensive. Alternatives need to be assessed. New zero carbon materials are not expected to satisfy global demand or meet cost supply requirements in the shorter term.

11.10 Workmanship

Standards are continually changing to keep pace with technological advance, regulatory requirement, skills availability and climate change. Weather remains an important consideration in determining work schedules, methods, precautions and seasonal advantage. Unexpected change usually brings delay. Even if this is an uninsured expense, it may lead to problems, e.g. 'cutting corners' with dangers of non-compliance. The importance of having a well-managed, experienced, skilled workforce cannot be over-emphasised.

Work patterns may need eventually to change – an increased summer temperature range may bring Mediterranean style working hours avoiding periods of maximum heat with 'siesta' time (Figure 2). Milder winters will extend periods for carrying out weather dependent operations, but curtail work in sub-Arctic regions.

New materials or manufacturing procedures, e.g. factory modules for site erection may need special assembly skills to minimise new inherent problems, such as prefabricated transit, heavy lifting, or damage due to unprotected offsite storage.

On-site responsibility for use of correct materials and contractor design will generally fall on designated project personnel where continuity of an experienced team needs to be maintained. Many site problems arise from poor supervision and lack of site knowledge. This is particularly important when working in an unfamiliar environment.

Overseas, the problems of skilled site supervision and climate awareness may become that much greater. Regulatory compliance and supervision may be found lacking, usually with hindsight, following a major natural exposure event, e.g. flood or earthquake.

Risk management must play a vital part to train those responsible in all work areas to be alert to change and take the right emergency course of action (Figure 9). Costs justifiably expended in mitigation of an insured loss occurrence should be recompensed by insurers who would otherwise have suffered a much larger potential loss. Warning periods, e.g. flood, can prove sufficient to significantly reduce a catastrophic loss. Evacuation of mobile plant is a priority.

Work schedules may be restricted due to seasonal climatic conditions. In alpine areas, works progress may be limited to eight months or less due to adverse site conditions which may also affect access supply routes. In tropical areas, seasonal monsoon periods should be avoided. Insurers may require that vulnerable works are secured until more favourable drier conditions return. Polar areas may witness extremes of climate change. Ice free arctic areas may bring about considerable benefit, e.g. shipping and mineral exploration.

An important sector of the workforce will fall within the SME category applicable to specialist professionals, trade personnel and self employed labour. Standards of workmanship can vary greatly between one project labour force and another. Demands for low energy housing may require special skills. This will likely reflect in the insurance experience when compared (see Chapter 8).

11.11 The eco-low budget building

The UK quest to achieve an affordable regeneration, low cost maintenance, energy efficient, low GHG emission, socially acceptable unit continues. But is it achievable and will higher standards increase or alter the insurance risk? Faults in design, standards of workmanship and materials systems used, may again generate large aggregations of costly rectification or premature demolition. Traditional building construction is unlikely to meet cost criteria, where essential infrastructure outlay must be taken into account. Climate change will need to be fully evaluated to obtain the 'ideal' residence. Retention of equity value is paramount for both purchasers and financiers with long-term mortgage commitments.

Ten new eco-towns are planned to be completed by 2020 with up to 200,000 new homes. The proposed shortlist of 15 includes the Thamesgate development (Box 7).

Much talk centres on zero carbon housing but what exactly is involved and how will insurers' risk exposures be changed? Can existing rates and terms be maintained as for current conventional construction? The ideal energy efficient unit is not the cheapest construction option. Two important points arise:

- The use of natural or manufactured materials requiring low emission production.
- The creation of a 'zero' low emission structure for its planned lifespan.

The benefits overall bearing in mind the essential requirement of being 'fit for purpose' are subject to much discussion and claims from competing interests, e.g. wood, steel, cement, reinforced concrete, masonry, bricks, uPVC. Not all will be suited to every situation. In fact the choice may prove very limited.

Cost determines the standards level and overall final material form and design, but before considering unit cost there must be added:

- Clean site acquisition costs including possibly 'brown field' pollutant clearance and added protection from natural risk potential, e.g. flood, subsidence, etc.
- Site supply infrastructure and access costs like roads, main utilities, services, etc.
- Higher risk geological ground conditions and environmental natural exposures, e.g. close proximity of mature trees, particularly oak, willow, poplar, on clay type soils[16] (Box 10).

EPC requirements will give guidance as to expected lifespan emission levels for regulated residential and commercial buildings.

Low erection costs may involve significant reduction in use of comparatively expensive materials and labour methods with a strong tendency towards factory modular

Figure 9: Zambesi flood Kariba Dam, Zimbabwe. February 1958 – completed May 1960.

Disaster can strike a construction site at any time. Temporary access works are particularly vulnerable as this river suspension bridge washed away by a flood torrent exceeding 16,000 cumecs.

Due to the experience of the site management and the benefits of an early flood warning, disaster was averted enabling the contractors to deliver on time (Oliver 1960). The temporary access bridge was not designed to withstand the full force of river flow. To avoid total loss of the mid-stream cofferdam[15] this was deliberately breached and flooded to lessen water pressure which would otherwise have destroyed this work resulting in much greater insurance loss and severe delay in completion.

[15] Temporary structure, e.g., sheet piled designed to exclude water from excavation work or provide a dry working area which would otherwise be below water level or waterlogged.

[16] Regulatory minimum 2.5 metre foundations may apply for traditional residential housing.

assembly requiring on-site erection upon prepared foundations. The manufacture of 'flat pack' housing is an interesting development. Light-weight construction components will be favoured against conventionally heavier materials. This building tends to prove vulnerable to extreme storm events. Will insurers apply standard rates and conditions? Certainly the risks during construction will be different.

Materials having short term economic advantage may suffer from not having a commensurate lifespan, therefore, needing earlier renewal than envisaged.

11.12 Operational insurance

Property insurers' risk exposures are primarily limited to physical loss or damage but with an increasing interest in consequential loss coverage. Normally excluded will be:

- Wear and tear, corrosion, erosion, rust and gradual deterioration – these may be accentuated by more aggressive climate conditions and natural weathering. Climatic weathering in some 'hostile' environments can be extreme. These risks may be qualified during construction to provide coverage where abnormal risk is present.
- Negative equity – a past problem with low cost system building. Low cost affordability does not necessarily mean long-term value. Costly rectification work may follow an unforeseen failure, e.g. Ronan Point Collapse 16.5.68.
- Efficacy, performance or financial guarantee. Latent or inherent defects cover may be available on Practical Completion usually for a period of ten 'decennial' or twelve years, but limited to specific risks, i.e. collapse with special provisions.
- General maintenance. Low cost against continual higher recurring expense.
- Obsolescence.
- Costs of regulatory compliance.

11.13 Recommendations

- **Sound underwriting is essential despite cyclical markets**. The potential downside has increased with the greater uncertainties of climate change combined with '3C' and rapid expansion of technical and economic development. To subsidise the 'poor' risk due to lack of recognition can only jeopardise overall financial results with inadequate retained reserves funding. "Low carbon" does not automatically indicate improved risk. Insurers must underwrite favourable and unfavourable risk factors objectively.
- **The insurance industry needs to address long-term construction risks**. Can insurers move away from their traditional short-term commitment, and provide multi-year cover, necessary to support long-term equity investment protection? PFI/PPP type projects now well exceed 20 years. Insurers' concerns are twofold:
    - To provide acceptable cover for potentially much greater hazard scenarios without suffering ruinous claims.
    - As investors, to avoid a 'property blight' scenario with consequent fall in asset values due to limitations or non-availability of insurable protection. Financial institutions are more inclined towards active participation in determining the scope of project insurance protection.

BOX 10
The old oak tree

A small housing estate developed over some 30 years, pre WW2. One house added an extension to their property mid 1960 which suffered subsidence damage. Their insurers sought to have the neighbour's tree felled, being the alleged cause. The neighbours petitioned that the mature preserved tree – over 100 years old – remain but, importantly, if the insurers were to succeed, they give an indemnity to all surrounding owners for damage which could clearly arise from heave, bearing in mind a predominantly underlying clay groundmass.

The subsidence cause was clearly inadequate extension foundations as no other owner had suffered subsidence damage. Removing the tree would have created the effects of a much wetter climate. Complex arguments can arise when considering alleged tree growth damage.

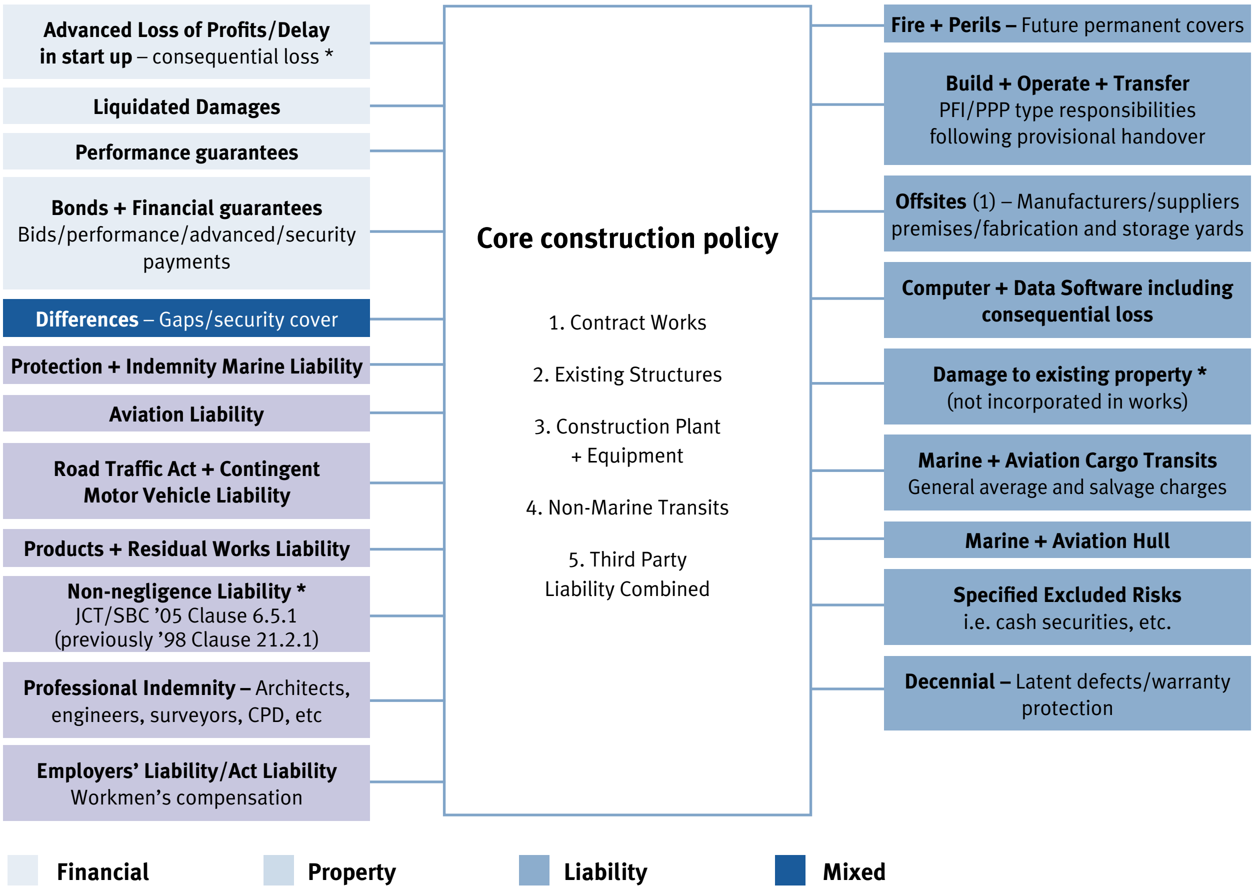
- **Insurers and Re-insurers must be prepared to innovate and adapt positively** and responsibly to the continuously changing global climate risk profile within sustainable limitations and demands for ever wider sophisticated economic protection. Traditional departmental restraints need to be overcome – the wider forms of CAR Insurance bear witness to what might be achieved.

However, for the major project some twenty plus separate forms of insurance need consideration – only a few of which will be catered for under a Standard Construction or Erection policy (Diagram 4).

Diagram 4: Core construction policy

Relationship with other insurance covers which may need be considered to provide a comprehensive project insurance risk management programme.

N.B. Climate change considerations apply generally and are not limited to the Core Policy.



Notes

a Where supplementary cover is arranged, gaps in protection afforded must be avoided wherever possible.

b The extent of other separate insurance will vary greatly from project to project depending on specific circumstances.

c Other forms of cover may be needed – Environmental Impairment, Breach of Restrictive Covenant, Directors and Officers Indemnity.

* May be included within main core policy 3) 4) and 5) may be the subject of separate covers or supplement core policy protection, i.e. excess third party liability.

The range of interests to be considered for the major project is far reaching (Diagram 5).

The variations, interdependence and extent of construction works is very wide indeed with large projects comprising major works in their own right.

Diagram 5: Separate risk considerations for the major construction project

Pre - site	To site	Site	Off site	Post - site
Feasibility study	Accessibility	Occupation	Mobilisation	Maintenance
Environmental acceptance	Essential infrastructure services in place	Mobilisation	Non-site facilities, e.g. storage and assembly workshops	Performance guarantees/ warranties
Planning approval	Transport – freight – marine and land based	Labour	Manufacturers	Latent defects
Conceptual to detailed engineering	Importation and customs	Temporary and permanent works	Suppliers	- 'Decennial'
Budget and costing estimates		Temporary accommodation, admin. facilities, installations.	Quarry/dredging operations	
Risk assessment and insurance protection		Workshops	Infrastructure support, e.g. essential services	
Financing and guarantees		Storage		
Tender submissions		Construction plant and equipment		
Tender evaluation within established budget		Testing and commissioning		
		Training		
		Maintenance		

Those requiring insurance include –

- Principals – owners, developers, financiers.
- Professional – Architects, Consulting Engineers, Designers, Surveyors, Study Bureaux, Insurance brokers, Risk managers.
- Contractors – on and off site, sub-contractors, supporting trades, personnel.
- Suppliers – primary, e.g. aggregates or part of supply chain, manufacturers.
- Transportation – Forwarding agents, hauliers, shippers.

There is plentiful scope for **product development** and **risk management partnerships** therefore, as climate and environmental change are important considerations for all participants.

- **Insurers should not rely on past experience** as their guide for the future. Design criteria, materials used, specifications and work practices change rapidly and continue to adapt to those required for the modern age. Insurers must be proactive in their risk analysis.
- **Weather risks present some of the major hazards** during a building construction works progress, continuing into post completion usage and operation. Sound risk management planning becomes essential, not to unnecessarily restrict development but to complement the 'entrepreneur project' and achieve a lasting insurable outcome. Without proper forethought, the cost of continuing maintenance, renewal and upgrading could becomes prohibitive. Even minor localised environmental change can bring the effects of a major climate change catastrophe, e.g. Hallsands (Box 8).
- **The insurance community must actively engage in programmes of continuous professional development** both individually and as a whole, to ensure its ability to respond to those reliant on risk management and pre-determined protection. A sound combined knowledge not only of insurance but the technical aspects of the subject matter to be insured. Close liaison and cross-fertilisation with other relevant professional bodies becomes a necessity. How else can sound and reliable standards of underwriting be set for a very technical form of insurance?
- **Expert advice on climate change is essential.** It is clear that already the climate has changed, and this trend will continue. The problem for insurers is how to satisfactorily assess risk – taking the worst scenario approach is not cost sustainable. Expert predictions may vary considerably, but wider safety margins seem more prudent than just ignoring the issue. Potential risk accumulation and regional aggregation loss are key factors. (See Chapter 3 for a full discussion of climate change science).
- **Insurers must engage responsibly in the construction project as early as possible.** Unless a clear statement of intent is made known at an early planning stage, difficulty arises later should restrictions be imposed or rejection become necessary. Also, once insurers' terms for a construction project are accepted they are binding with little opportunity to alter agreed terms. Insurers need therefore to continually observe change which might prejudice their risk and express views at an early stage, e.g. an unplanned river diversion, or changes in design procedures or materials used.
- **Insurers need to review their protective measures conditions** to safeguard their position, e.g. where essential work is not carried out within an agreed timeframe or does not meet acceptable standards for engineering and building.

  Following the major Broadgate (Figure 3) and London Underwriting Centre construction fire losses, the standard JCT contract terms, currently SBC 2005, were redrafted to incorporate for large contracts – compliance provisions relating to The Joint Fire Code of Practice. For floodplain or other exposed risk areas as part of overall risk management, similar voluntary Codes of Practice might be applied. Design, materials and usage are all important aspects for consideration. Insurers must actively engage the recommendations of the Pitt Report 2008 not only in relation to planned surface water management by the Environment Agency but incorporate all aspects of climate change potential. A strong insurance viewpoint needs be established regards acceptability of new development and protection of present and future 'hotspots'.

  Problems such as coastal erosion and rising water tables need to be addressed. Some property insurers' exclusions can prove to have a very wide interpretation.
- **Failure analysis** can provide valuable 'field' experience to determine future design and work guidelines. Failure evaluation can highlight the inherent dangers of changes which, at the time of planning, were considered insignificant. Hindsight is not a good defence but rather a warning for the future.
- **Insurers should ensure that project risk analysis includes "3C"** as well as the general global aspects of Climate Change. Each project has the potential to modify local climate. Environmental change during works progress can materially alter risk exposures. Could such have been foreseen? Should insurers have provided for potential change within their offered terms or covered the possibility of its occurrence?
- **CII should take an active role within the global climate change debate** as a focal point for their global membership, local and overseas representation and indirectly the insurance community. Risk protection is a prime global concern, particularly with newly developing overseas areas keen to acquire the professional knowledge and skills required. The '3C' debate will prove very relevant when considering developed economies and their expansion and regeneration needs. The CII needs to retain and expand its leading role.

Bibliography

Diagrams

1 Examples of '3C' Construction Climate Change

2 '3C' Natural Hazard Consideration Guide

3 '3C' Human Influenced Hazard Consideration Guide

4 Core Construction Policy

5 Separate Risk Considerations for the Major Project

Boxes

1 Byrd Close

2 Nevado del Ruiz and Aberfan Disasters

3 Hallsands

4 Mega City Development

5 Storm Effects on a Salt Marsh

6 China

7 Thames Gateway Development

8 The Vajont Dam Disaster

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3 Inner City Development

4 The Expanding City

5 Thames Flood Barrier

6 Infrastructure Planning

7 Heritage Retention

8 High Rise Design

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Abbreviations Used

'3C' The Construction Climate Change Concept

BNI British Nuclear Insurers

BOT Build + Operate + Transfer

CAR Construction All Risks Insurance including Third Party Risks

$CaCO_3$ Calcium Carbonate

CH_4 Methane

CO_2 Carbon dioxide

CPD Contractors Part Design – JCT SBC 2005

CUMECS Cubic Metres per Second – Water Flow

EPBD Energy Performance of Buildings

EPC Energy Performance Certificate

EU European Union

FIDIC Federation Internationale des Ingenieurs-Conseils

GHG Greenhouse Gas

HAC High Alumina Cement

IPCC Intergovernmental Panel on Climate Change

JCT The Joint Contract Tribunal Ltd

LSE London School of Economics and others

MPH Miles Per Hour

NHS The National Health Services

ODA Olympic Delivery Authority

OECD Organisation for Economic Co-operation and Development

PFI Private Finance Initiative

pH Standard scale for measuring Acid/Alkali balance in soil/water

PPP Private Public Partnership

SBC Standard Building Contract

SME Small Medium Sized Enterprises

SSSI Special Site of Scientific Interest

UK United Kingdom – Great Britain

uPVC Unplasticised Polyvinyl Chloride

WTC World Trade Center – New York, US

WW2 World War Two

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Diagrams 2 & 3
Based on classification and extracts from 'The Earth in our Hands' – The Geological Society, London

Box 1 Nevada del Ruiz: Earth – Luhr J. Aberfan: Geography – an integrated approach – Waugh D

Box 2 Mexico City: 'Geographical' – Royal Geographical Society. Natural Disasters – Davis L

Box 4 The Environment Agency – 'East Anglian Saltmarshes'

Fig. 3 Encyclopaedia of London – Weinreb and Hibbert

Box 5 Extracts from recent media publications – 'Daily Telegraph', 'Time', 'Fortune' and 'Construction News'.

Box 6 The Environment Agency – TE2100; The Thames Waterway Plan; The Thames Barrier. RSPB – Wallasea Island Nature Reserve Project

Fig. 8 Sky High – Abel C. Royal Society of Arts

Box 7 Geography – an integrated approach – Waugh D. A Geology for Engineers – Blyth & de Freitus

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Biography

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In 1953 John joined Sedgwick Collins and after early experience on large industrial and engineering risks, joined their international special risks construction team. In 1972, he left to establish Lowndes Lambert Group Construction Division becoming managing director. In 1980, as a founder director, he assumed a similar role with John Plumer & Partners now incorporated within the Arthur J. Gallagher Group. Since 1990 he has worked as an independent consultant.

A past CII and CIS prize winner, he has acquired considerable international experience of major building, civil engineering, oil, energy and water-related projects.

He was an active member of the Institute of London Advanced Study Group 2008 relating to Construction Insurance, the Climate Change and Insurance Research Report 2001 and is currently author of the Construction sections of the 'Kluwers Handbook of Insurance'.

John's interests include heritage, biodiversity and environmental conservation. He is an amateur geologist and a long standing member of the Geologists Association.