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6TH ANNUAL CONSTRUCTION RISK MANAGEMENT CONFERENCE

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MANAGING HEALTH & SAFETY (H&S) DURING THE SIX PROJECT STAGES TO REDUCE RISK

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Introduction

- Projects entail a number of stages
- Projects entail a number of stakeholders
- Historically:
  - H&S and other risk related issues have been the contractor's responsibility
  - Risk has been transferred to the contractor
- Section 10, OH&S Act No. 85 of 1993
- 2003 and now 2014 Construction Regulations
- Inadequate or the lack of H&S negatively affects project risk – 95.8% of responding project managers (Smallwood, 1996)
- Projects entail many risks:
  - Not just H&S
  - However, the focus of this presentation is on H&S

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Six project stages

- Project initiation and briefing
- Concept and feasibility
- Design development
- Tender documentation and procurement
- Construction documentation and management
- Project close out
- Plus (not recorded in the respective identities of work):
  - Use
  - Deconstruction

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Macro Construction H&S environment

Construction H&S occurs in a macro environment:

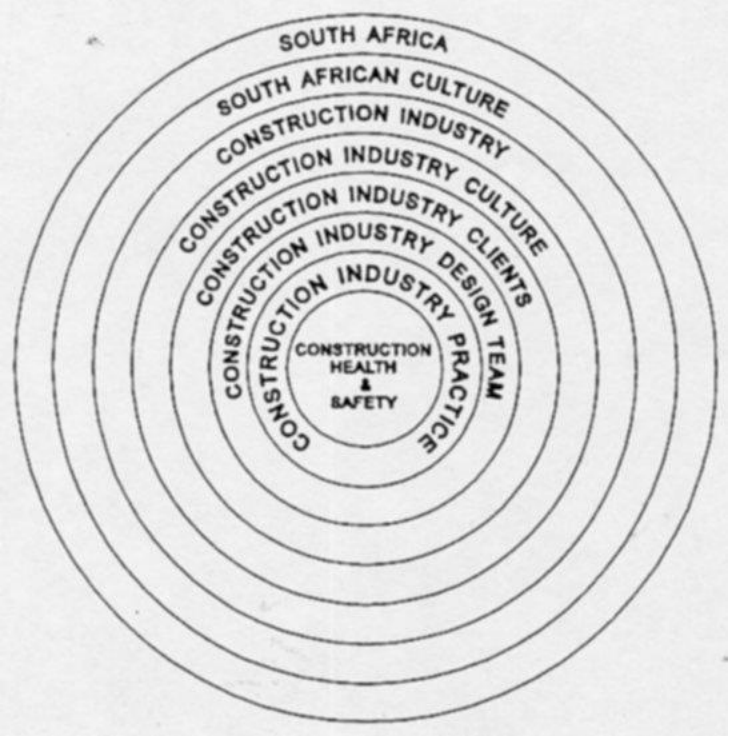

Figure 1: Construction H&S – the macro environment (Smallwood, 1995)

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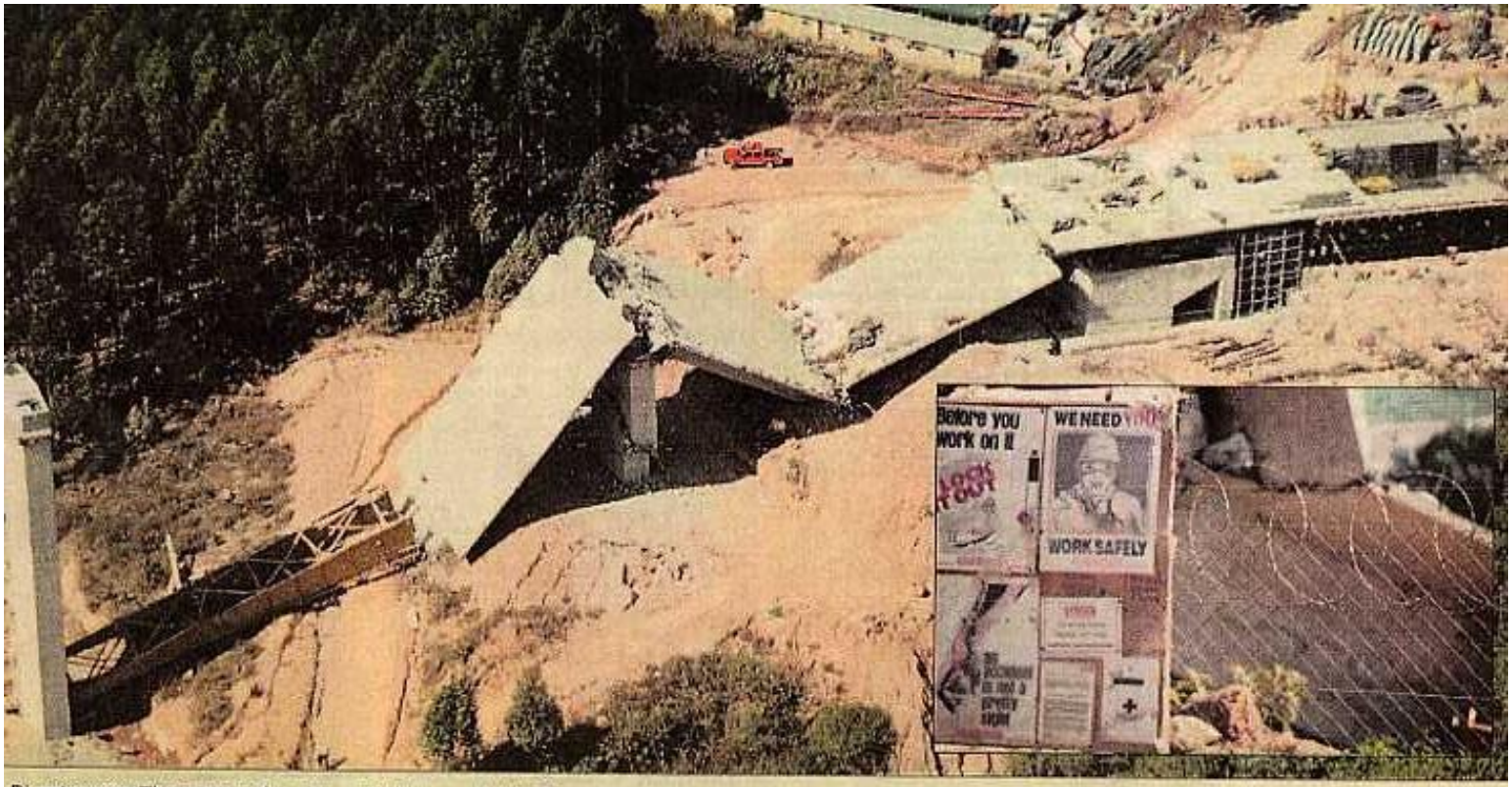
Injaka Bridge collapse (1)



Disaster area: The construction of a road bridge near Injaka Dam turned into disaster when it collapsed, instantly killing 12 people and injuring 15. Two of the injured died later. Insert - A reminder to workers of the dangers of working on a construction site. Full update on page 2. **Photographs by Raymond Travers.**

Injaka Bridge collapse, Mpumalanga, July, 1998 (Travers, 1998)

Injaka Bridge collapse (2)

Department of Labour (2002):

- Causes:
  - The slide path was not under the webs
  - The placing of the sliding pads between the deck and temporary bearings was not as specified
  - Insufficient reinforcement in the deck section, especially the bottom slab
  - The failure to fully appreciate the implications of the early cracks
  - The acceptance and approval of a launching nose which was substantially less stiff than that prescribed in the project specification
  - The deviation from the project specification regarding the automatic pier deflection monitoring at pier 2
  - The deviation from the project specification regarding the height tolerances of the temporary bearings on pier 3
  - The use of design and construction personnel, at decision-making level, without appropriate qualification and experience in incremental launched bridges

Injaka Bridge collapse (3)

- No independent design reviews were conducted of either the temporary or permanent works

- Contributory causes:
  - The lack of experience on the part of design personnel in incremental launching techniques resulted in poor communications between the parties to clarify understandings and interpretations regarding the slide path position
  - The lack of clear instructions in the project specification and clear indications on the consulting engineers design drawings as to the position of the sliding path, resulted in incorrect interpretations being made

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H&S is a profit centre not a 'cost'

- Based upon the value of construction work completed in the year 2002, namely R 56 343m (South African Reserve Bank, 2003) the total COA could have been between 4.3% (R 2 401.2m / R 56 343m), and 5.4% (R 3 041.5m / R 56 343m) (Smallwood, 2004)
- Cost of prevention is between 1% and 2%

Risk management (1)

- Risk introduces potential variability in outcomes
- Risk is not complementary to the business of construction and projects
- Project risk management is 1 / 9 project management knowledge areas
- There are numerous risks in construction, H&S included
- Built environment is not renowned for risk management
- The lack of aversion to risk does not complement construction H&S
- Clients, project managers, designers, quantity surveyors / cost engineers, and construction managers especially should adopt a formal risk management process
- Quantify the risks, rank, and evolve appropriate responses where required

Risk management (2)

- **Beware of 'low probability / high impact' risks e.g. Injaka Bridge**

Integration of design and construction (1)

- Two issues - influence of design on construction H&S, and the type of procurement system
- Design influences construction directly and indirectly:
  - Directly, through design, choice of structural frame, details, method of fixing, constructability, and specification of materials and finishes
  - Indirectly, through choice of procurement system and conditions of contract, procurement, decision regarding project duration, and reference to H&S on various occasions
- Certain procurement systems such as design-build promote the integration of design and construction
- Optimum integration engenders and enhances H&S as it facilitates contractor contributions to the design process
- Designing for H&S is one of sixteen design for constructability principles – contractors can contribute

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Integration of design and construction (2)

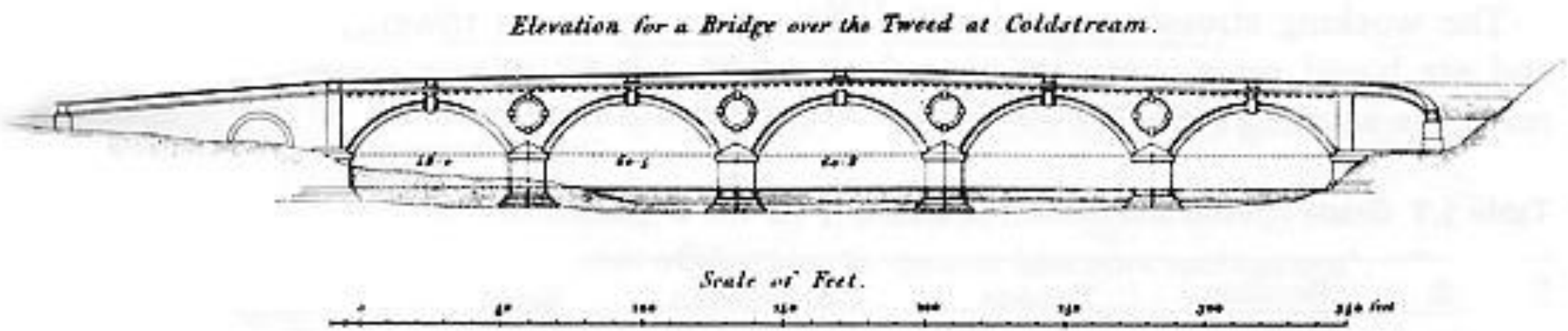


Figure 2: Elevation of masonry Bridge over the Tweed at Coldstream, 1866 (Irwin and Sibbald, 1983)

Integration of design and construction (3)

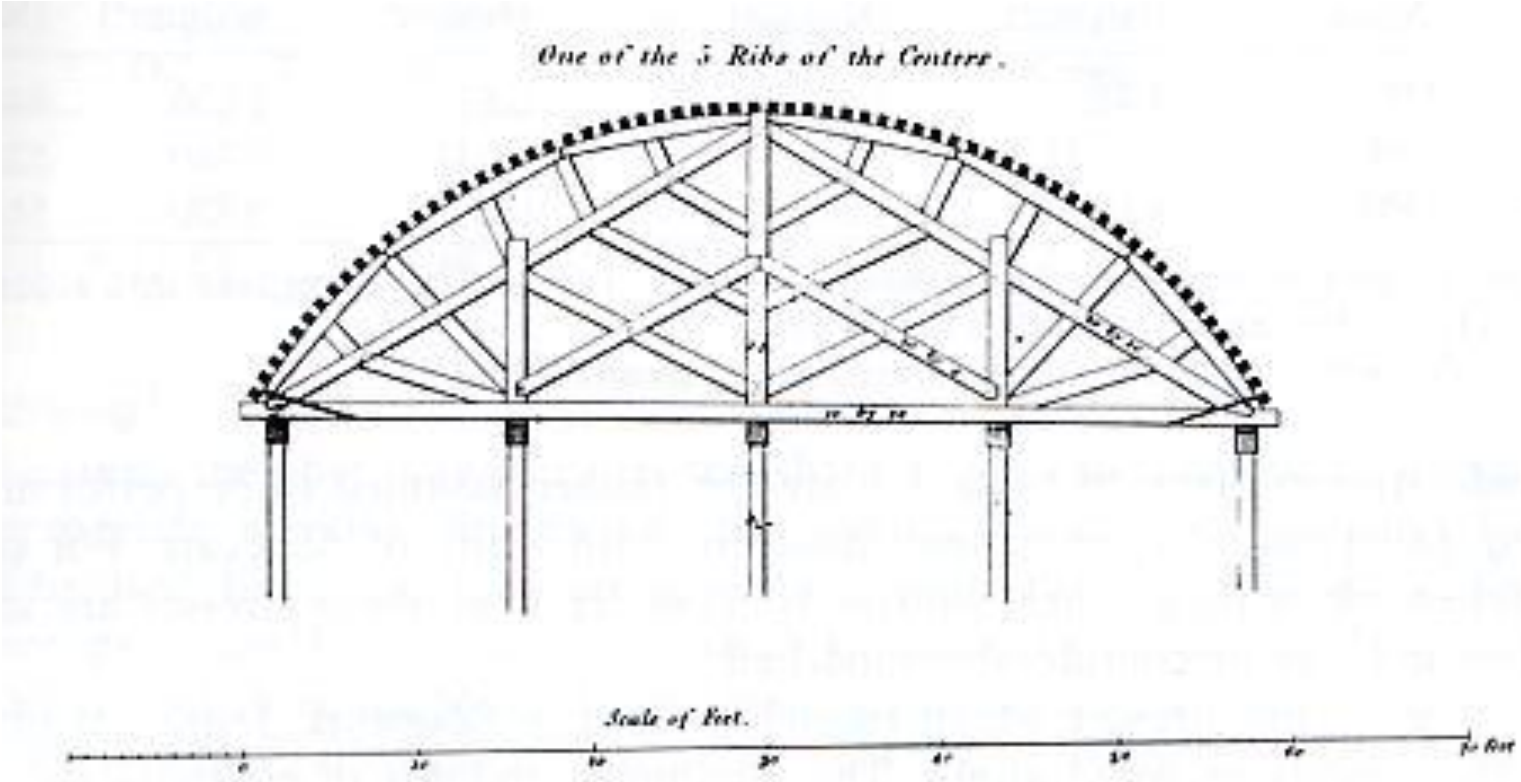
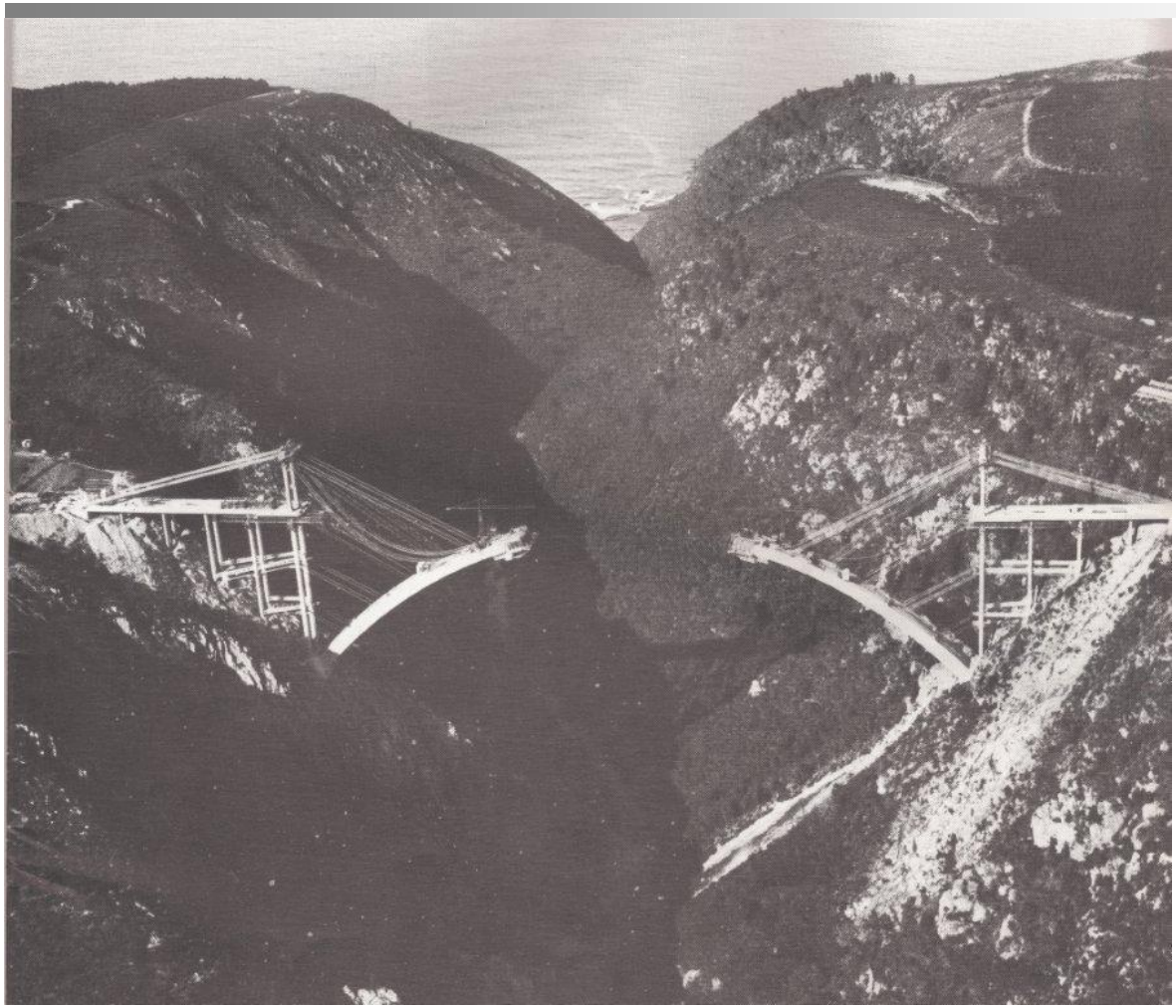


Figure 3: Centering for masonry Bridge over the Tweed at Coldstream, 1866 (Irwin and Sibbald, 1983)

Integration of design and construction (4)



Bloukrans Bridge (p. 11, Concrete Beton, 1983)

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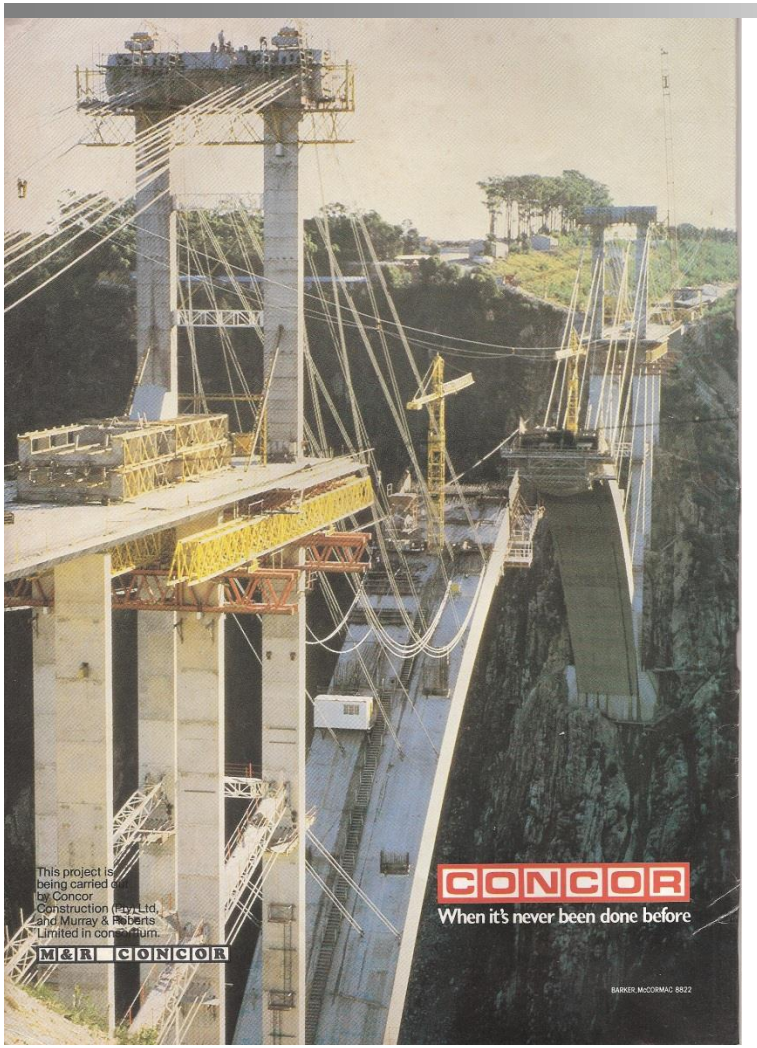
Integration of design and construction (5)



Bloukrans Bridge (Inside Front, Concrete Beton, 1983)

Integration of design and construction (6)

Bloukrans bridge project (Steele, 1983):

- **"…notable for the close cooperation and team effort which were achieved by the consultant and contractor, and encouragement given by the client."**
- **"… consulting engineers had clearly indicated in their design how the task should be tackled and worked closely with the contractors in converting the drawings they had supplied to reality…"**

Construction Regulations (1)

- Definition of 'designer' – a competent person who:
  - prepares a design
  - checks and approves a design
  - arranges for a person at work under his / her control to prepare a design including an employee of that person
  - designs temporary work including its components
- An architect or engineer contributing to, or having overall responsibility for a design
- Building services engineer designing details for fixed plant
- Surveyor specifying articles or drawing up specifications
- Contractor carrying out design work as part of a design and build project
- Interior designer, shop-fitter, or landscape architect

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Construction Regulations (2)

- Relative to Structures 6 (1) designers of a structure must:
- (a) ensure that the H&S standards incorporated into the regulations are complied with in the design
- (b) take the H&S specification into consideration
- (c) include in a report to the client before tender stage:
  - all relevant H&S information about the design that may affect the pricing of the work
  - the geotechnical-science aspects
  - the loading that the structure is designed to withstand
- (d) inform the client of any known or anticipated dangers or hazards relating to the construction work, and make available all relevant information required for the safe execution of the work upon being designed or when the design is changed
- (e) modify the design or make use of substitute materials where the design necessitates the use of dangerous procedures or materials hazardous to H&S

Construction Regulations (3)

- (f) consider hazards relating to subsequent maintenance of the structure and make provision in the design for that work to be performed to minimize the risk
- (g) when mandated by the client conduct inspections to ensure conformance of construction to design. If not mandated then the client's agent is responsible
- (h) when mandated by the client stop construction work not in accordance with the design's H&S aspects. If not mandated then the client's agent is responsible
- (i) when mandated by the client, during his / her final inspection of the structure include the H&S aspects of the structure, declare the structure safe for use and issue a completion certificate

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Construction Regulations (4)

- Clients required to, among other:
- 5 (1) (a) Prepare a baseline risk assessment (BRA)
- 5 (1) (b) Prepare an H&S specification based on the BRA
- 5 (1) (c) Provide the designer with the H&S specification
- 5 (1) (d) Ensure that the designer takes the H&S specification into account during design
- 5 (1) (e) Ensure that the designer carries out the duties in Regulation 6 'Duties of designers'
- 5 (1) (f) Include the H&S specification (revised after the designers' reports?) in the tender documents
- 5 (1) (g) Ensure that potential PCs have made provision for the cost of H&S in their tenders
- 5 (1) (h) Ensure that the PC to be appointed has the necessary competencies and resources

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Project initiation and briefing (1)

- Quality management system (QMS)
- Client brief:
  - Client H&S goals
  - Client requirements
  - Client responsibilities
  - H&S information
  - Client interventions / contributions
- Client baseline risk assessment (BRA)
- Concept design hazard identification and risk assessment (HIRA)
- H&S measurement e.g. No. of H&S issues raised
- ‘See the end at the beginning’

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Project initiation and briefing (2)

Bahia Temple, Delhi, India (Smallwood, 2005)

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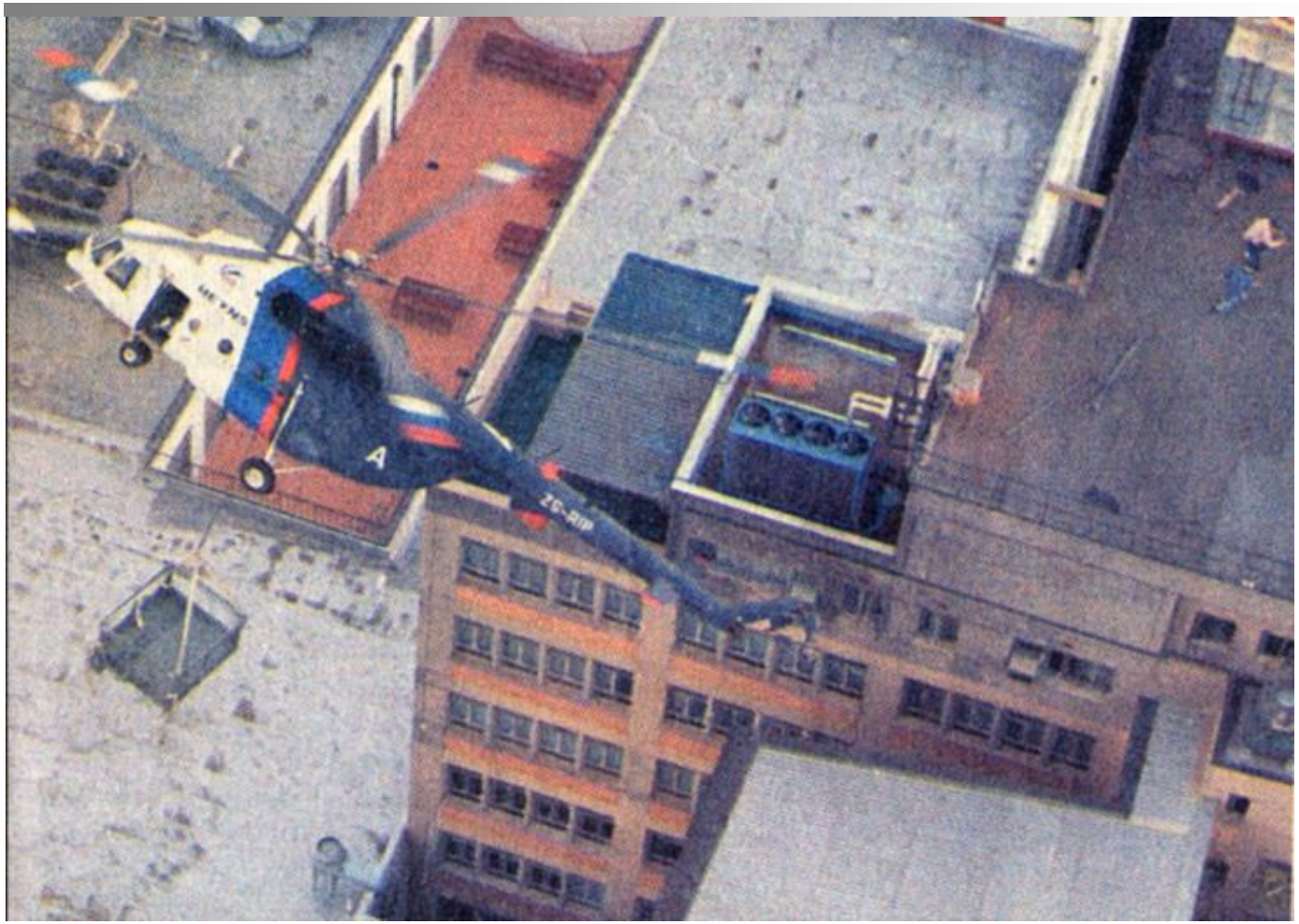
Project initiation and briefing (3)



Helicopter crash, Strand Street, Cape Town (Vosloo, 1999)

Project initiation and briefing (4)

Helicopter crash, Strand Street, Cape Town (Vosloo, 1999)

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Project initiation and briefing (5)

Helicopter crash, Strand Street, Cape Town (Vosloo, 1999)

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Project initiation and briefing (6)

FLAMES OF DEATH . . . The Russian Mi-8 helicopter crashes into the roof of Boston House in Cape Town's central business district early yesterday. A professional photographer, who had been photographing the helicopter as it loaded airconditioning equipment onto the building, ended up capturing these images of a horrific accident in which four people died. Pictures: AP

Helicopter crash, Strand Street, Cape Town (Amalgamated Press, 1999)

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Concept and feasibility (1)

- Quality management system (QMS)
- Appointment of H&S Agent
- Client baseline risk assessment (BRA)
- H&S specification
- Concept design hazard identification and risk assessment (HIRA)
- H&S measurement e.g. No. of H&S issues, and design changes due to HIRAs
- ‘See the end at the beginning’

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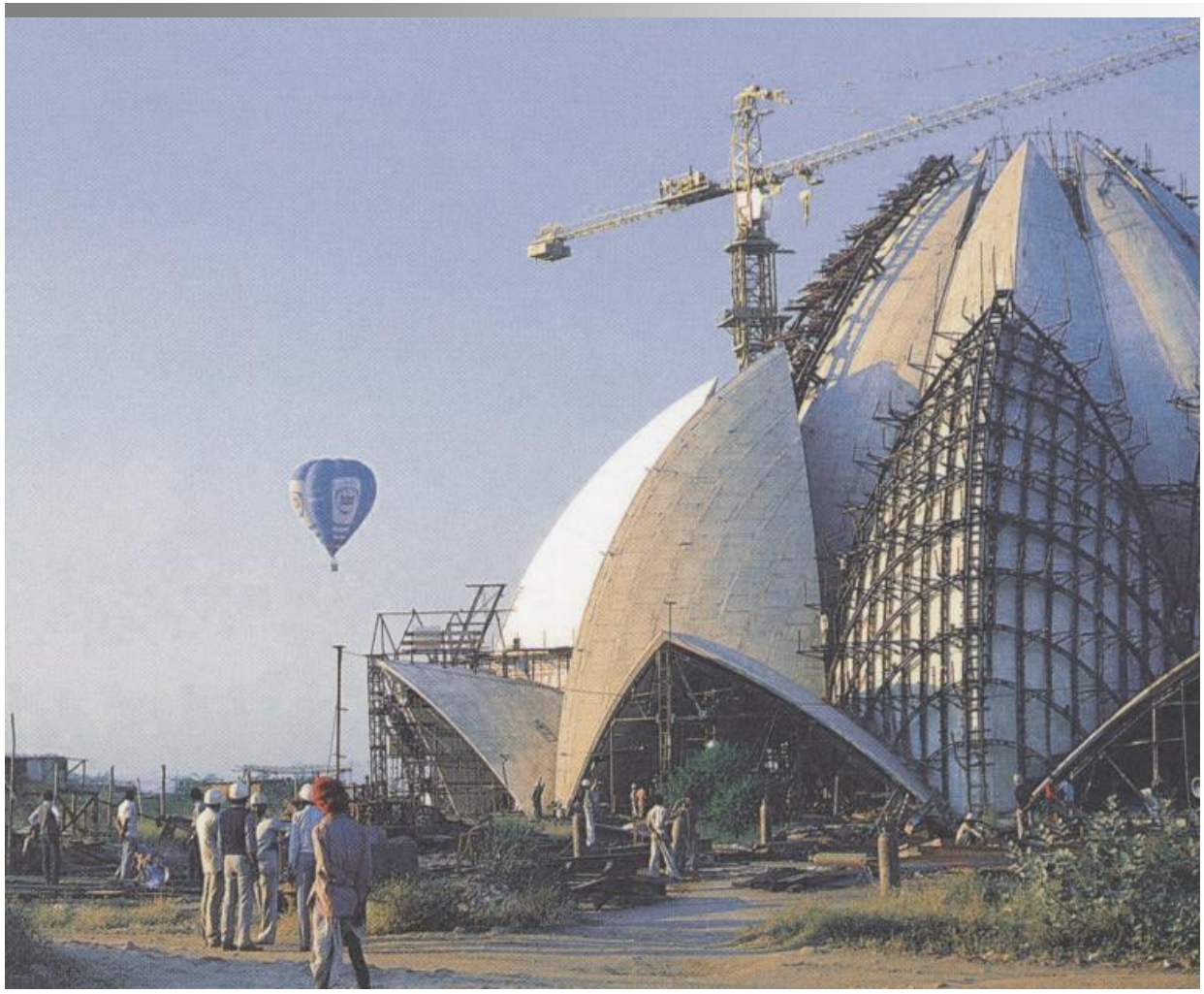
Concept and feasibility (2)



Bahia Temple, Delhi, India (The National Spiritual Assembly of the Bahia'is of India, 2002)

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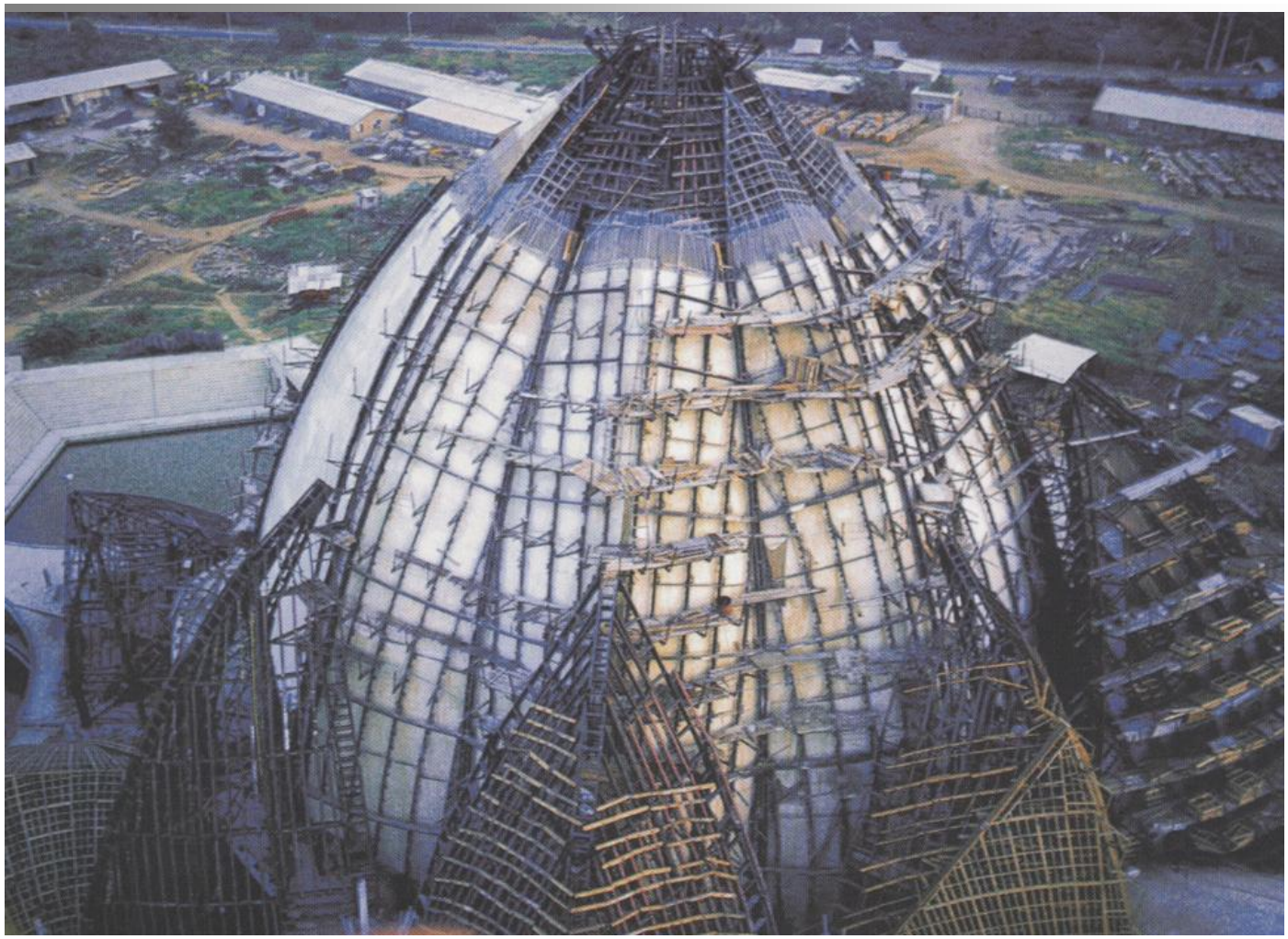
Concept and feasibility (3)



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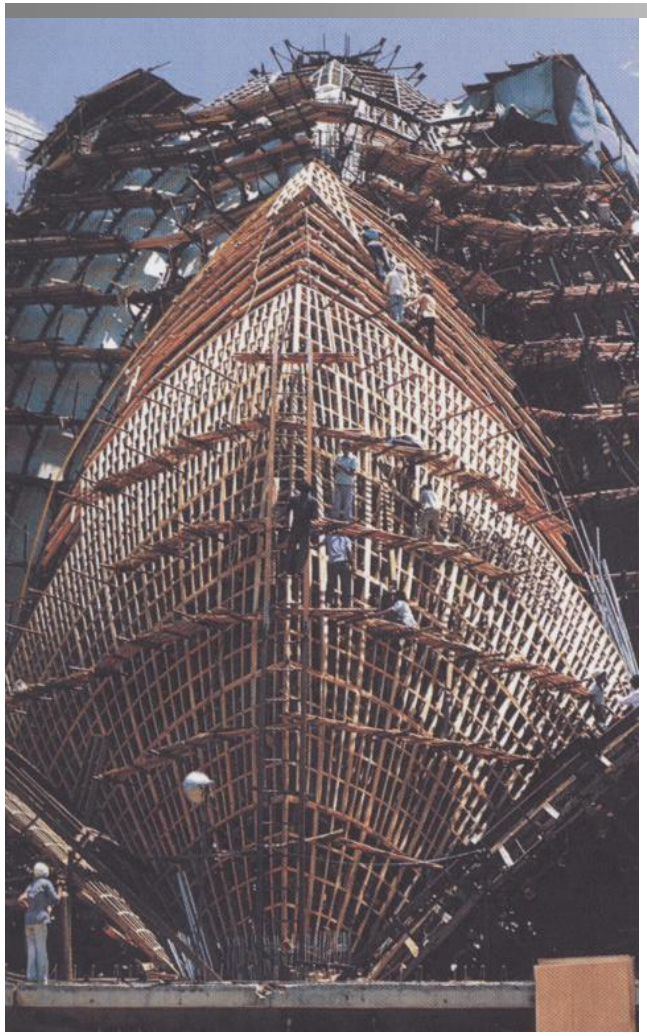
Concept and feasibility (4)



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Concept and feasibility (5)

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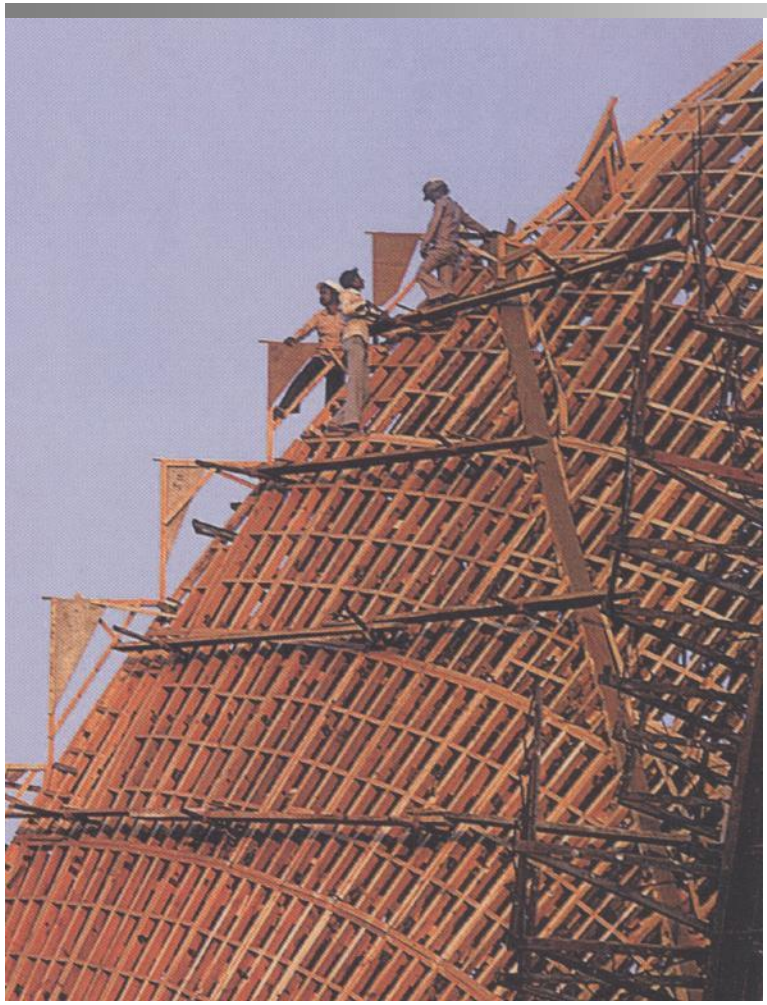
Concept and feasibility (6)



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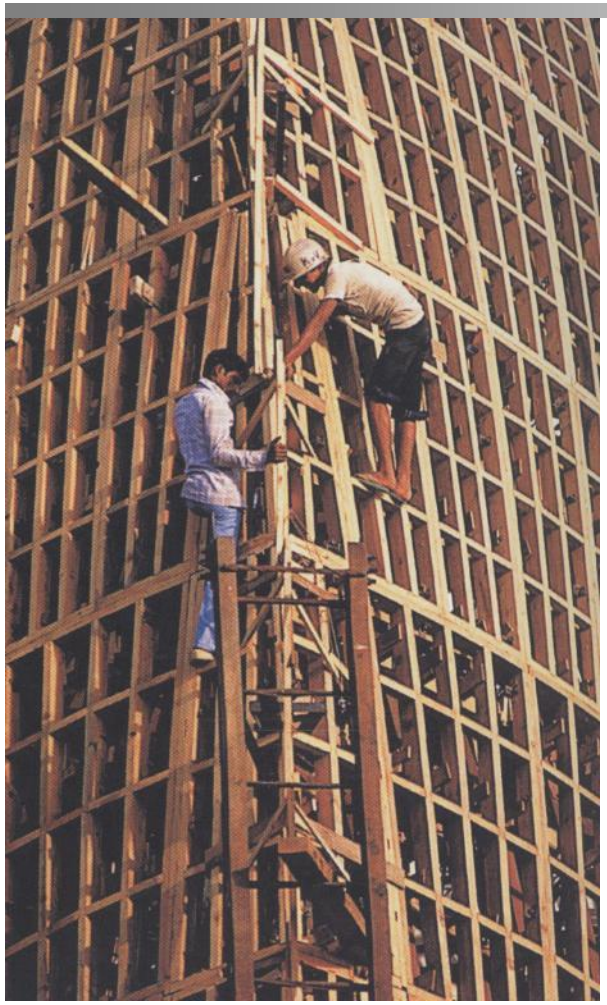
Concept and feasibility (7)



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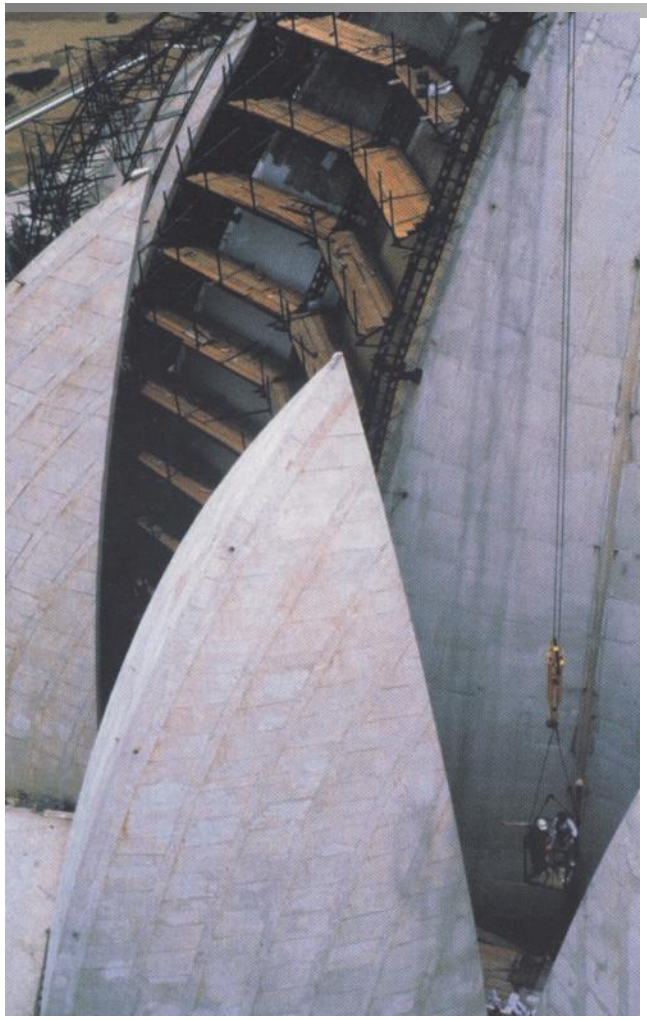
Concept and feasibility (8)



Bahia Temple, Delhi, India (The National Spiritual Assembly of the Bahia'is of India, 2002)

Reduction of risk through design (1)

(Steel Construction, 2004)

Reduction of risk through design (2)

(Steel Construction, 2004)

Reduction of risk through design (3)

(Steel Construction, 2004)

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See the end at the beginning (1)

Stellenbosch Collapse (Anonymous, June 2008)

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See the end at the beginning (2)

Stellenbosch Collapse (Anonymous, June 2008)

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See the end at the beginning (3)

Stellenbosch Collapse (Anonymous, June 2008)

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Detailed design (1)

- Quality management system (QMS)
- H&S information
- Detailed design hazard identification and risk assessments (HIRA)
- Coordination of design
- Constructability reviews
- Designer 'H&S' report
- 'Design and construction' method statements
- H&S specification (Revised by client)
- H&S measurement e.g. No. of H&S issues, and design changes or substitutions due to HIRAs
- 'See the end at the beginning'

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Designing for H&S (1)

Precast concrete stair flights, Port Elizabeth (Smallwood)

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Designing for H&S (2)

Precast concrete stair flights, Port Elizabeth (Smallwood)

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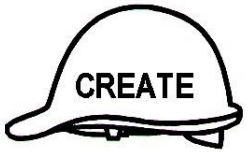
Designing for H&S (3)

Plank and hollow-block composite slab, Plettenberg Bay (Hamp-Adams, 1994)

Designing for H&S (4)



An example of a generic risk assessment form (GRA) -Page 1				
NAME OF ORGANIZATION				
NAME OF PROJECT				
ACTIVITY COVERED	Erecting precast plank and hollow block composite slab			
SIGNIFICANT HAZARDS		ASSESSMENT OF RISK		
		LOW	MEDIUM	HIGH
1	People falling			3 X 3 = 9
2	Materials falling			3 X 2 = 6
3	Collapse of structure	1 X 3 = 3		
4	Pinching	3 X 1 = 3		
5	Manual handling			3 x 2 = 6
6	Tripping			3 x 2 = 6
7	Failure of blocks (material)			2 X 3 = 6

Figure 4: Design HIRA for erecting precast plank and hollow block composite slab

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Designing for H&S (5)

Pre-cast pre-stressed hollow core slab section (SA Builder Bouer, 2004a)

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Designing for H&S (6)

Pre-cast pre-stressed hollow core slab section (SA Builder Bouer, 2004b)

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Designing for H&S (7)

Occasion (Stream)	Architects		Arch. Tech's		Mean	
	Mean Score	Rank	Mean Score	Rank	Mean Score	Rank
Detailed design (Upstream)	3.83	1	3.30	2=	3.57	1
Working drawings (Upstream)	3.65	2	3.32	1	3.49	2
Concept (design) (Upstream)	3.61	3	3.30	2=	3.46	3
Preparing project documentation	3.46	4	2.81	5	3.14	4
Site inspections/discussions	3.38	5	2.84	4	3.11	5
Site meetings	3.35	6	2.73	6	3.04	6
Design coordination meetings	3.32	7	2.65	7	2.99	7
Client meetings	2.97	9	2.54	8	2.76	8
Constructability reviews	3.06	8	2.41	9	2.74	9
Site handover	2.80	10	2.16	10	2.48	10
Deliberating project duration	2.76	11	1.86	12=	2.31	11
Pre-qualifying contractors	2.51	13	1.97	11	2.24	12
Pre-tender meeting	2.57	12	1.78	14	2.18	13=
Evaluating tenders	2.50	14	1.86	12=	2.18	13=

Table 1: Frequency at which Architectural practices and Architectural Technologists consider / refer to construction ergonomics on various occasions (MS: 1.00 – 5.00) (Smallwood, 2009).

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Designing for H&S (8)

Aspect	Architects		Arch. Tech's		Mean	
	Mean Score	Rank	Mean Score	Rank	Mean Score	Rank
Plan layout	3.81	1	3.38	1=	3.60	1
Design (general)	3.75	3	3.38	1=	3.57	2
Details	3.78	2	2.97	6	3.38	3
Method of fixing	3.67	4	3.03	4	3.35	4
Specification	3.63	5	3.00	5	3.32	5
Position of components	3.38	7	2.97	7	3.18	6
Elevations	3.18	10	3.16	3	3.17	7
Finishes	3.50	6	2.65	11	3.08	8
Type of structural frame	3.17	11	2.92	9	3.05	9
Site location	2.96	14	2.95	8	2.96	10
Schedule	3.04	12	2.81	10	2.93	11=
Edge of materials	3.24	8	2.62	12	2.93	11=
Texture of materials	3.21	9	2.38	15	2.80	13
Content of material	3.01	13	2.54	13	2.78	14
Surface area of materials	2.79	15	2.41	14	2.60	15
Mass of materials	2.54	16	2.35	16	2.45	16

Table 2: Frequency at which Architectural practices and Architectural Technologists consider / refer to construction ergonomics relative to various design related aspects (MS: 1.00 – 5.00) (Smallwood, 2009

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Designing for H&S (9)

Aspect	Architects		Arch. Tech's		Mean	
	Mean Score	Rank	Mean Score	Rank	Mean Score	Rank
Design (general)	3.83	1	4.08	2	3.96	1
Details	3.72	2	4.05	4	3.89	2
Plan layout	3.57	4	4.08	3	3.83	3
Position of components	3.50	5	4.03	5	3.77	4
Method of fixing	3.58	3	3.83	9	3.71	5
Site location	3.23	9	4.11	1	3.67	6=
Finishes	3.47	6=	3.86	8	3.67	6=
Edge of materials	3.26	8	3.94	6	3.60	8
Specification	3.47	6=	3.70	11	3.59	9
Type of structural frame	3.15	10	3.89	7	3.52	10
Elevations	3.06	13	3.81	10	3.44	11
Texture of materials	3.11	11	3.56	14	3.34	12
Schedule	3.02	14	3.60	13	3.31	13=
Mass of materials	2.97	15	3.65	12	3.31	13=
Content of material	3.08	12	3.44	16	3.26	15
Surface area of materials	2.73	16	3.46	15	3.10	16

Table 3: Extent to which various design related aspects impact on construction ergonomics according to Architectural practices and Architectural Technologists (MS: 1.00 – 5.00) (Smallwood, 2009).

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Tender documentation and procurement

- Client, project manager and design team:
  - Quality management system (QMS)
  - Optimum project duration
  - Contract documentation – reference to H&S
  - H&S specification (Revised)
  - Provision for equitable allowance for H&S
  - H&S pre-qualification
  - Ensure adequate allowance for H&S
- Contractors:
  - Pre-tender and pre-contract planning:
    - Site layout
    - Programme
    - Method statements
  - H&S plan
- H&S measurement – leading versus trailing

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Construction documentation and management (1)

- Quality management system (QMS)
- H&S management system
- Planning:
  - Programme
  - H&S plan
  - Method statements
- Temporary works design
- H&S appointments
- H&S training
- Construction hazard identification and risk assessment (HIRA)
- H&S meetings
- H&S inspections
- H&S measurement – leading versus trailing e.g. percentage of activities for which safe work procedures exist
- H&S file

Construction documentation and management (2)

Coega Bridge collapse, Port Elizabeth, November, 2003 (Markman, 2003)

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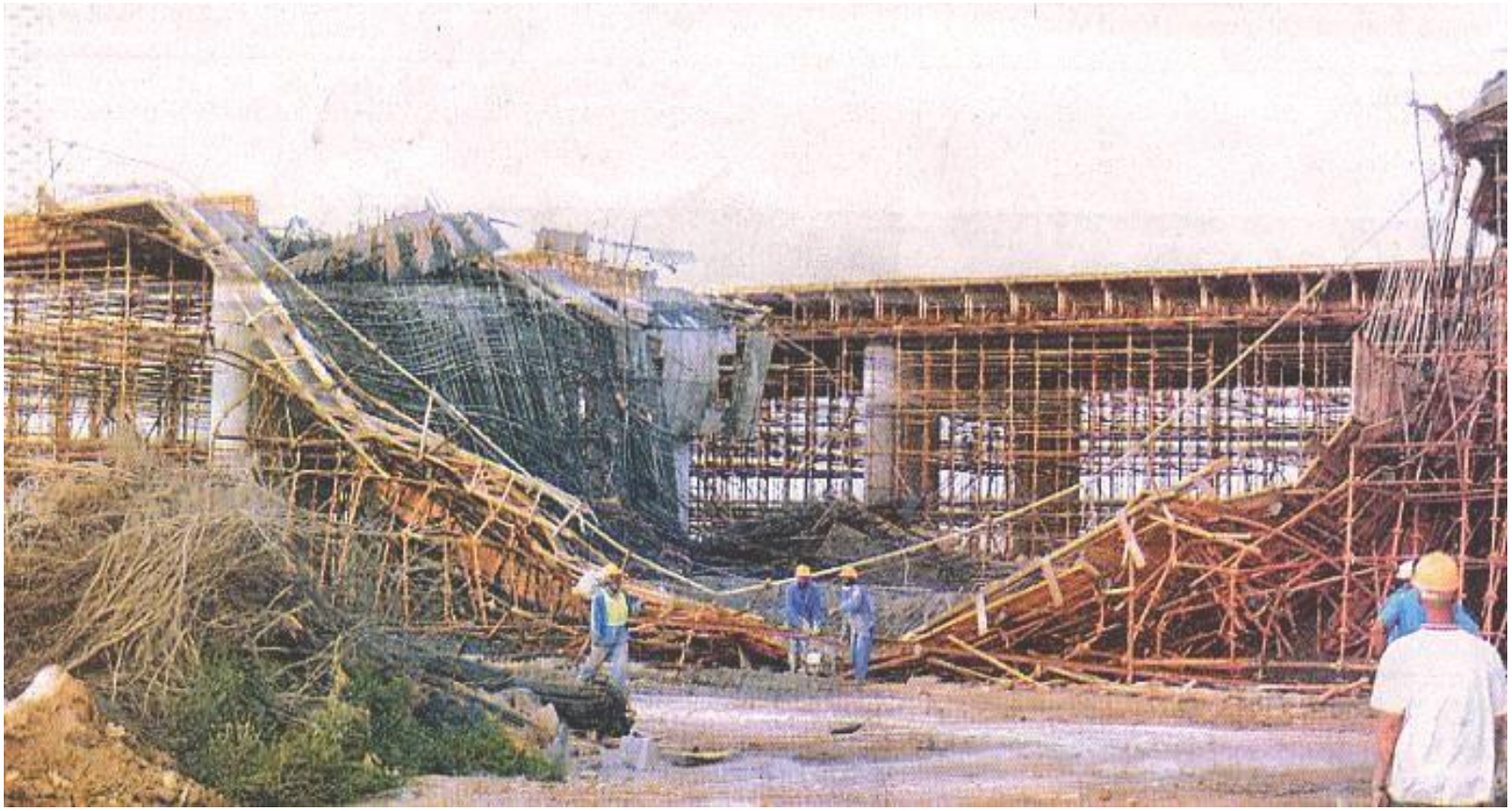
Construction documentation and management (3)



Coega Bridge collapse, Port Elizabeth, November, 2003 (Markman, 2003)

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Project close out

- As built and as laid drawings
- H&S file – finalise
- H&S measurement – trailing indicators e.g. disabling injury incidence rate (DIIR)
- Project close out report

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Use and deconstruction

- Use:
  - Inspections of the structure
  - H&S file
- Deconstruction:
  - Start all over again – the six stages
  - H&S file

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Key points (1)

- Risks, but they can be managed – mitigated or eliminated
- Construction is not inherently dangerous – strategies, systems, procedures, and protocol
- All accidents are preventable
- Accidents = Failure of management
- Reengineer the built environment and construction
- Adopt systems thinking to address H&S complexity
- H&S is a profit centre not a 'cost'
- Optimum H&S culture - H&S is a value not a priority
- Integrate H&S into all six project stages plus use and deconstruction stages
- Design for H&S
- Committed and involved clients
- Competent project managers, designers, quantity surveyors / cost engineers, and construction managers

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Key points (2)

- QMSs
- H&S management systems
- Integrated multi-stakeholder project H&S plans
- Inclusive tertiary built environment education (construction H&S)

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