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THE COUNCIL FOR THE BUILT ENVIRONMENT (CBE) TRANSFORMATION INDABA
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MANAGING HEALTH & SAFETY (H&S) DURING THE SIX STAGES OF PROJECTS TO REDUCE RISK

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Introduction (1)

- 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 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

Introduction (2)

- The report 'Construction Health & Safety Status & Recommendations' highlighted the considerable number of accidents, fatalities, and other injuries that occur in the South African construction industry (Construction Industry Development Board (cidb), 2009):
  - High-level of non-compliance with H&S legislative requirements, which is indicative of a deficiency of effective management and supervision of H&S on construction sites as well as planning from the inception / conception of projects within the context of project management
  - Lack of sufficiently skilled, experienced, and knowledgeable persons to manage H&S on construction sites
  - The disabling injury incidence rate (DIIR) is a rate, per 200 000 hours worked, of disabling injuries due to all causes i.e. per 100 workers x 2 000 hrs / yr: 0.98
  - Fatality rate per 100 000 workers: 25.5

Introduction (3)

- International fatality rates:
  - Australia: 3.3 in 2016 (Safe Work Australia, 2017)
  - UK: 1.94 in 2015 / 2016 (Health and Safety Executive (HSE), 2016)
- The severity rate (SR) in turn indicates the number of days lost due to accidents for every 1 000 hours worked:
  - Construction (1.14) is the fourth highest, the all industry average being 0.59
  - Given that the average worker works 2 000 hours per year, if the SR is multiplied by 2, the average number of days lost per worker per year can be computed = 2.28 working days per worker, which is equivalent to 1.0% of working time
- The total cost of accidents (COA) could have been between 4.3% and 5.4%, based upon the value of construction work completed in South Africa (Smallwood, 2004 in cidb, 2009):

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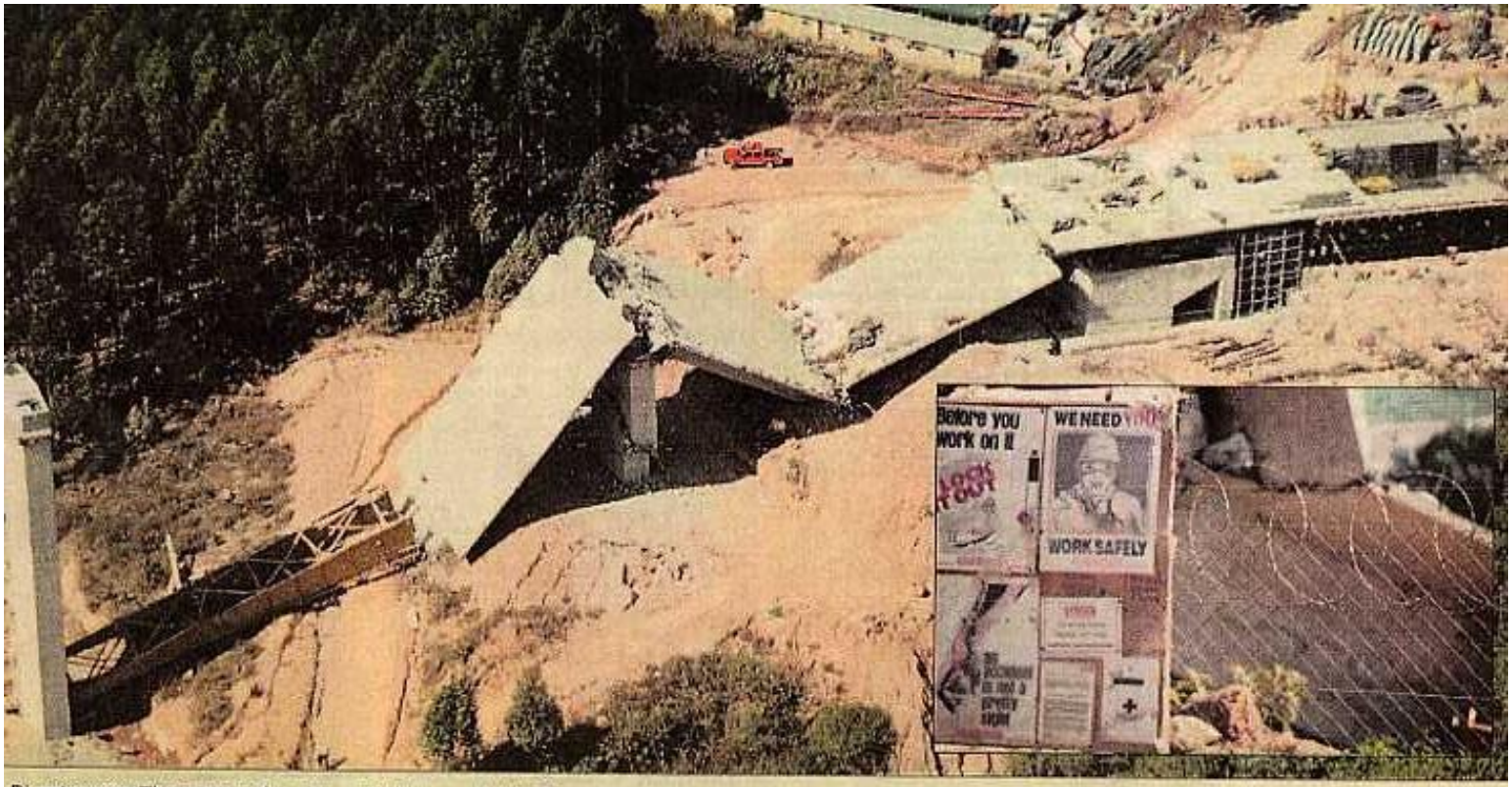
Six project stages

- 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 including maintenance
  - Deconstruction

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

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)

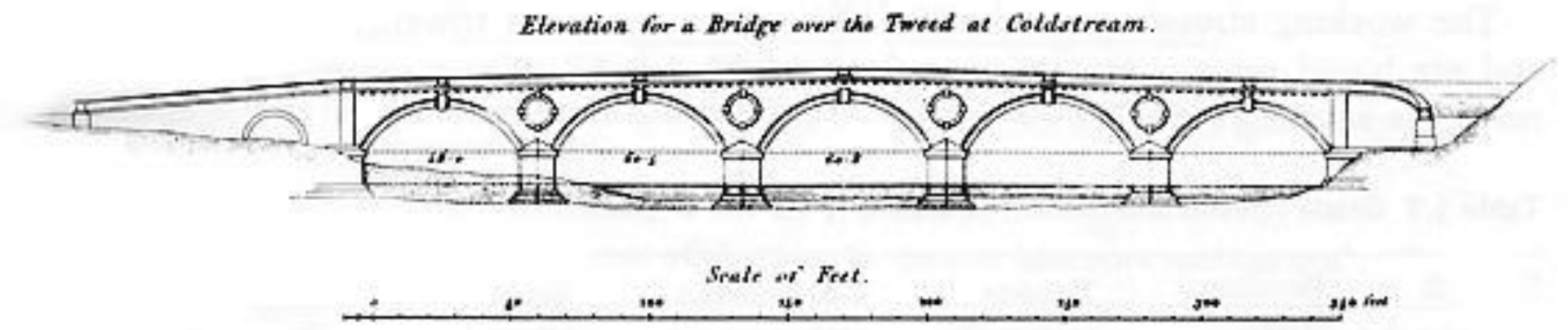

Figure 2: Elevation of masonry Bridge over the Tweed at Coldstream, 1866 (Irwin and Sibbald, 1983)

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Integration of design and construction (3)

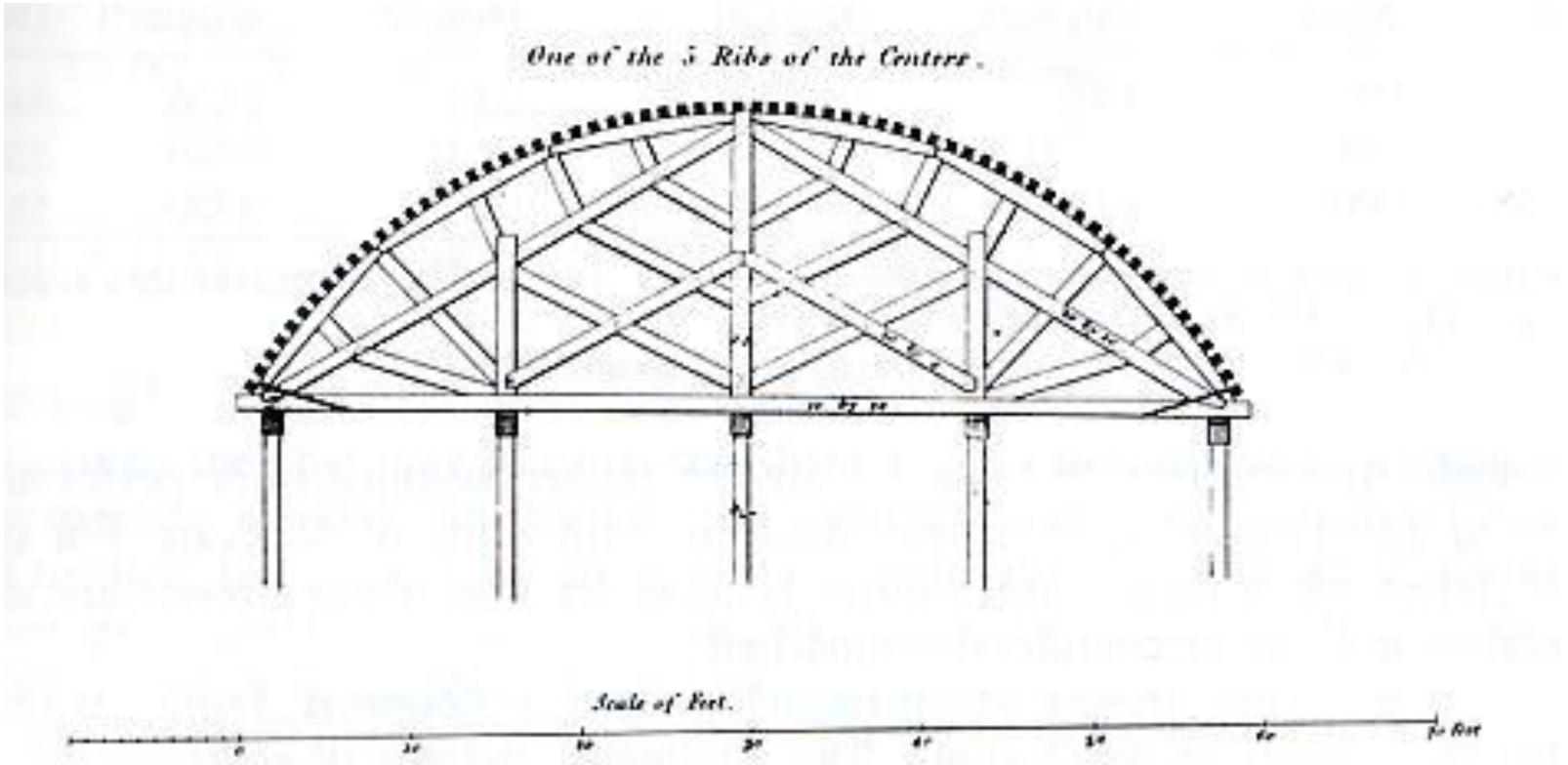
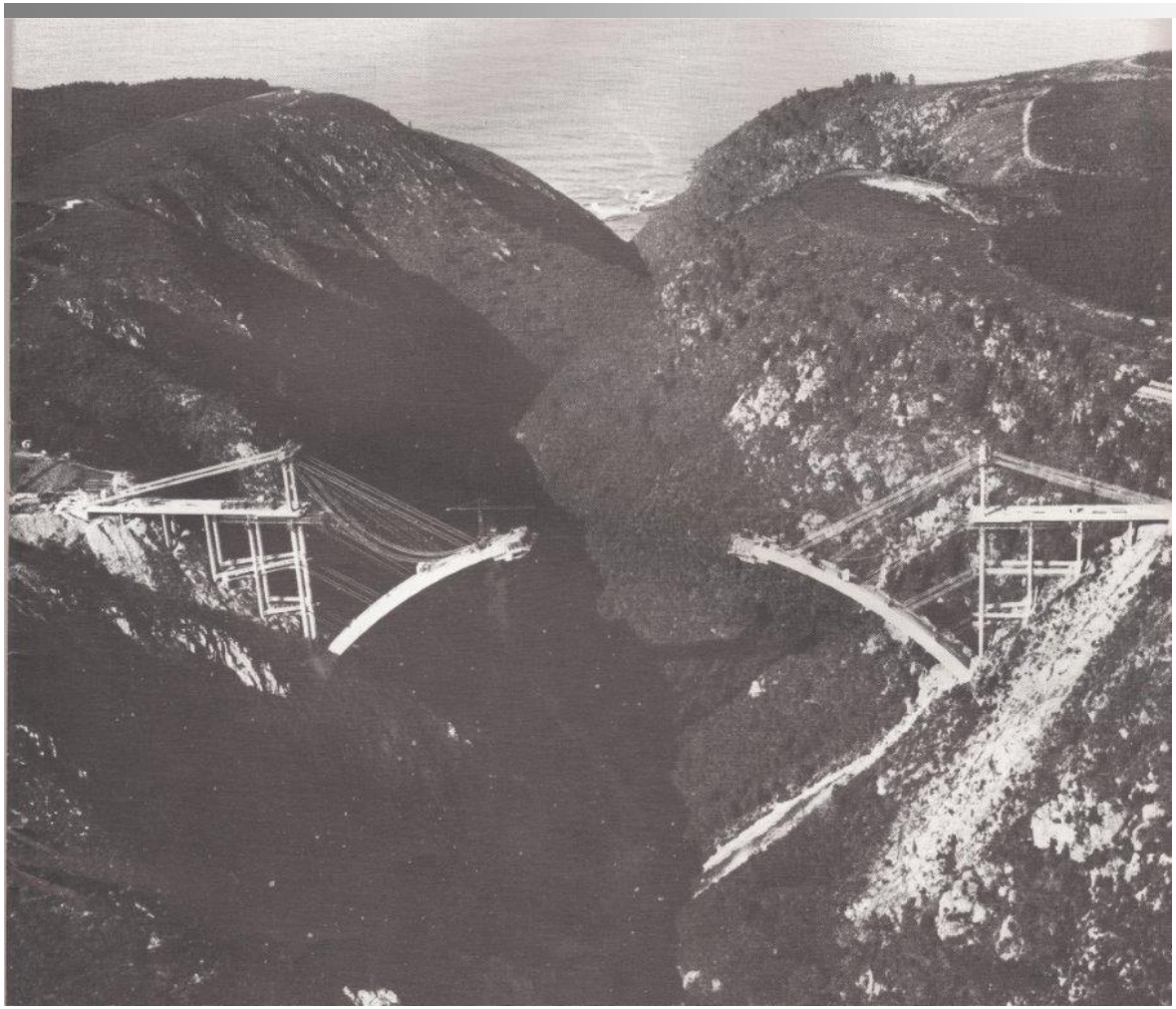


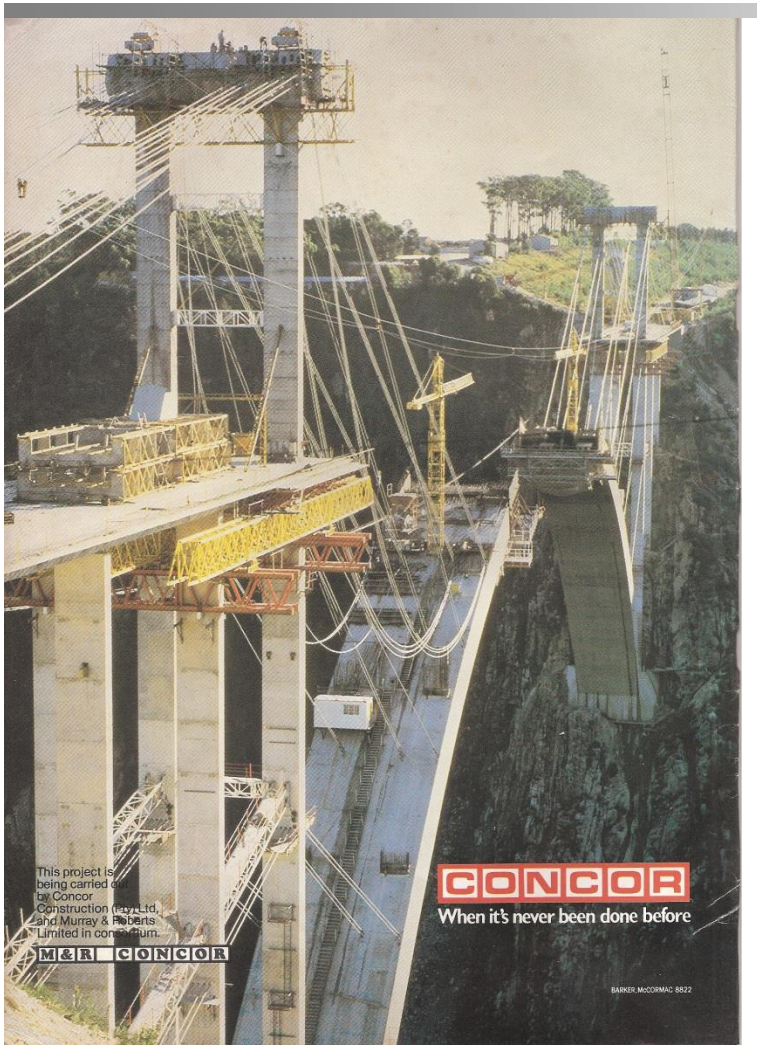
Figure 3: Centering for masonry Bridge over the Tweed at Coldstream, 1866 (Irwin and Sibbald, 1983)

Integration of design and construction (4)



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

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…"**

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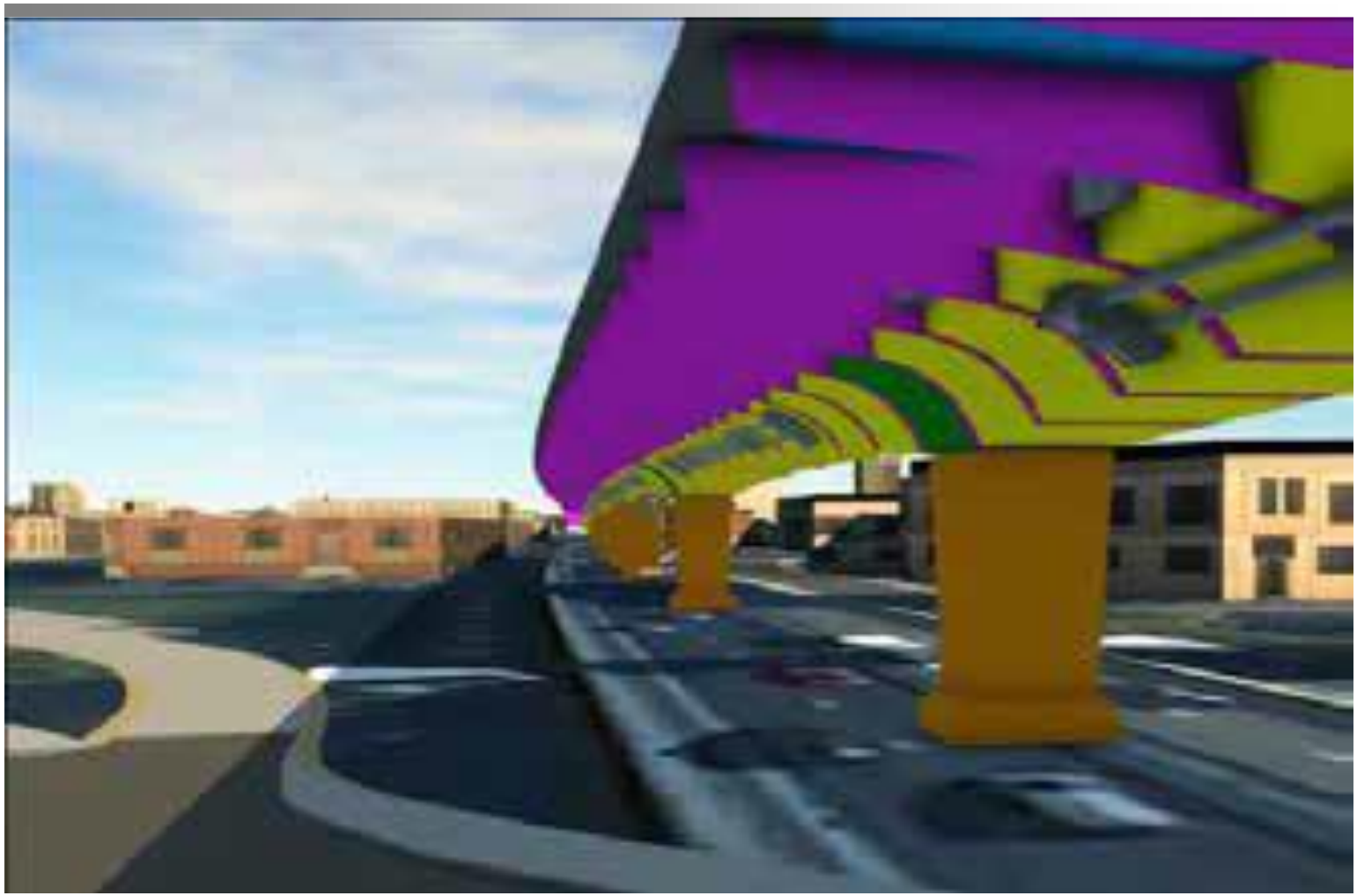
Building Information Modelling (BIM)

"Building Information Modelling (BIM) supports the digitisation of construction and uses information relating to the assets to build a three dimensional model with supporting intelligent, structured data attached to them. It is a way of working underpinned by digital technologies to unlock more efficient methods of designing, creating and maintaining assets. The information contained within the models facilitates better decision making, resulting in better business outcomes, improved communication, and enables de-risking of construction activities; all of which leads to improvements in efficiency." (HSE, 2018)

BIM: Hammersmith flyover (1)

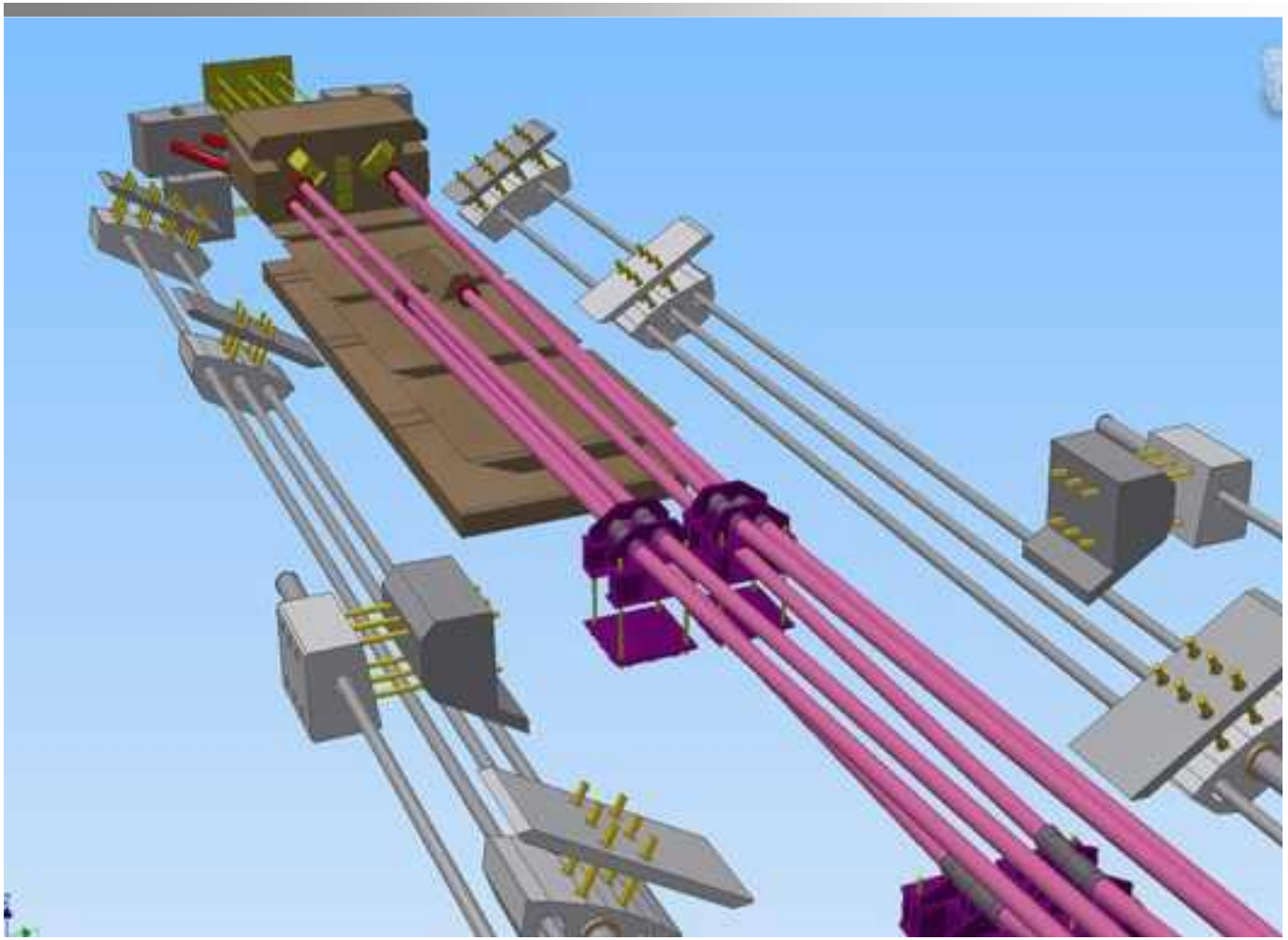
Actual photo of the flyover built more than 50 years ago (HSE, 2018)

BIM: Hammersmith flyover (2)



BIM model of the flyover (HSE, 2018)

BIM: Hammersmith flyover (3)

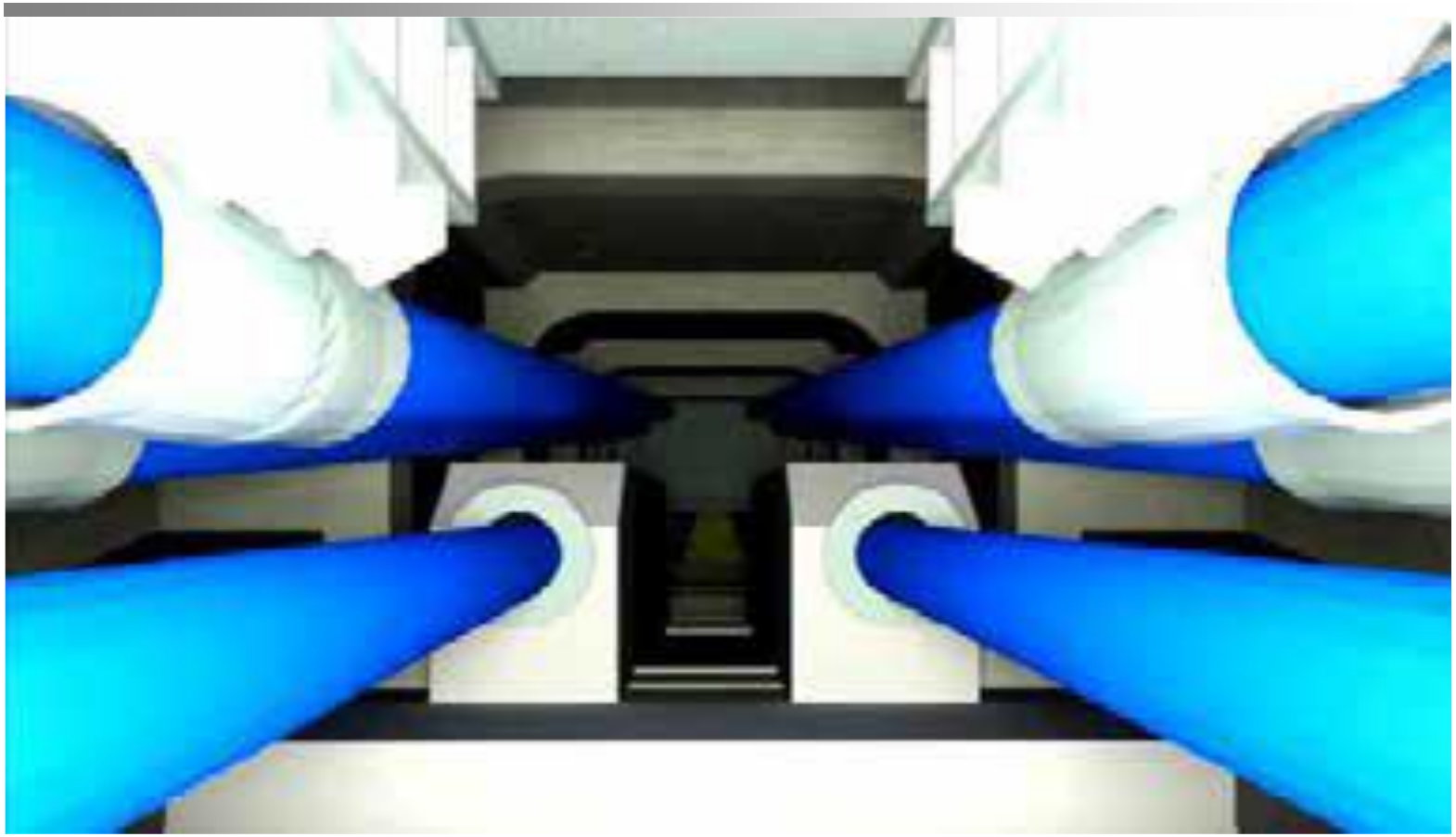


Proposed solution that can be installed alongside the flyover (HSE, 2018)

BIM: Hammersmith flyover (4)

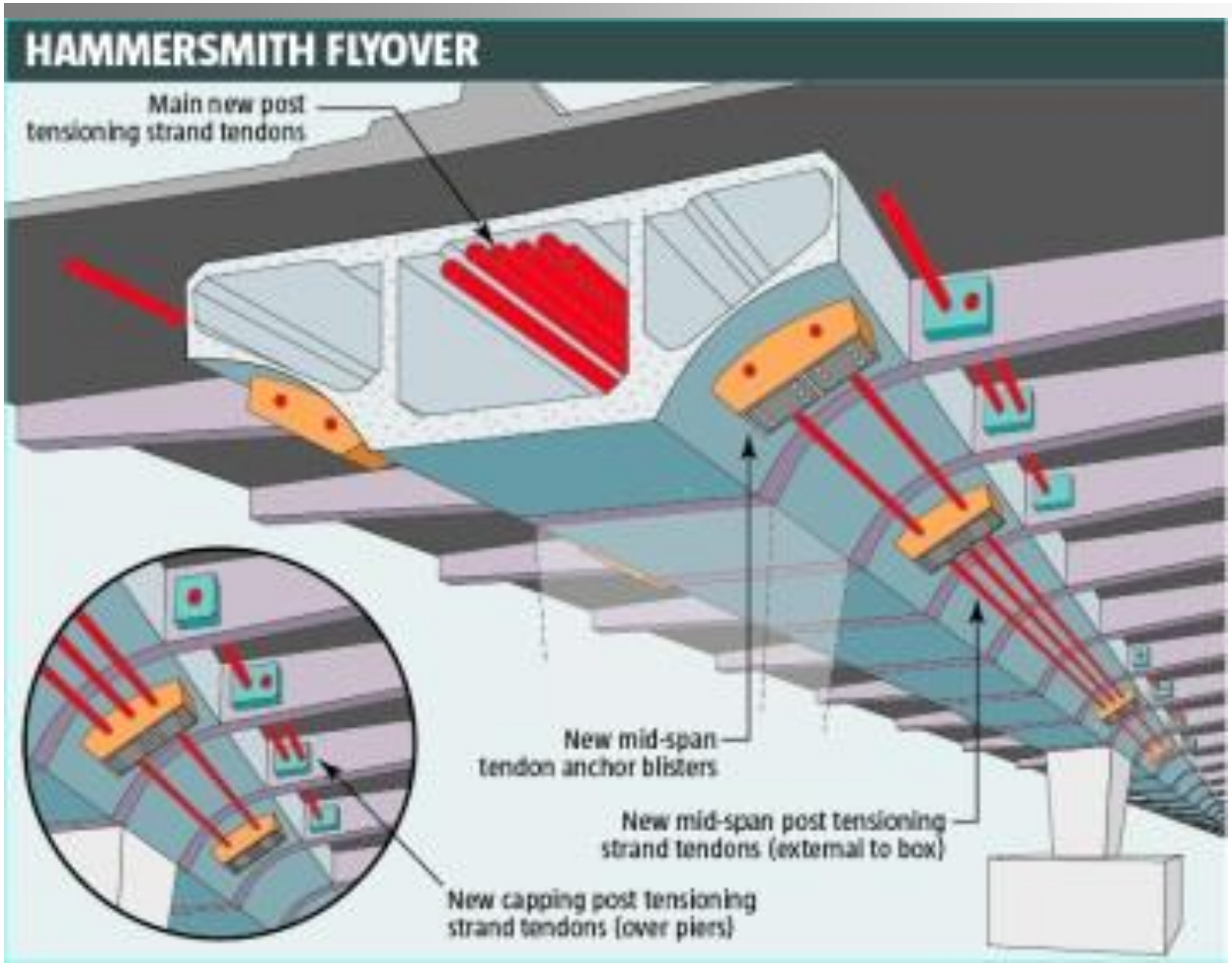
Access constraints while fitting the new tensioning tendons (HSE, 2018)

BIM: Hammersmith flyover (5)



BIM model showing as intended installation of the new tensioning tendons (HSE, 2018)

BIM: Hammersmith flyover (6)



BIM model showing as intended installation of the new tensioning tendons (New Civil Engineer, 2015)

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

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

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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)
- Appointment of H&S Agent
- Client brief:
  - Client H&S goals
  - Client requirements
  - Client responsibilities
  - H&S information
  - Client interventions / contributions
- Initiate integrated multi-stakeholder project H&S plans, environmental plans, quality plans, and risk management plans
- Client baseline risk assessment (BRA)
- Project initiation and briefing design hazard identification and risk assessment (HIRA) leading to the concept design HIRA

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Project initiation and briefing (2)

- H&S measurement e.g. No. of H&S issues raised
- ‘See the end at the beginning’

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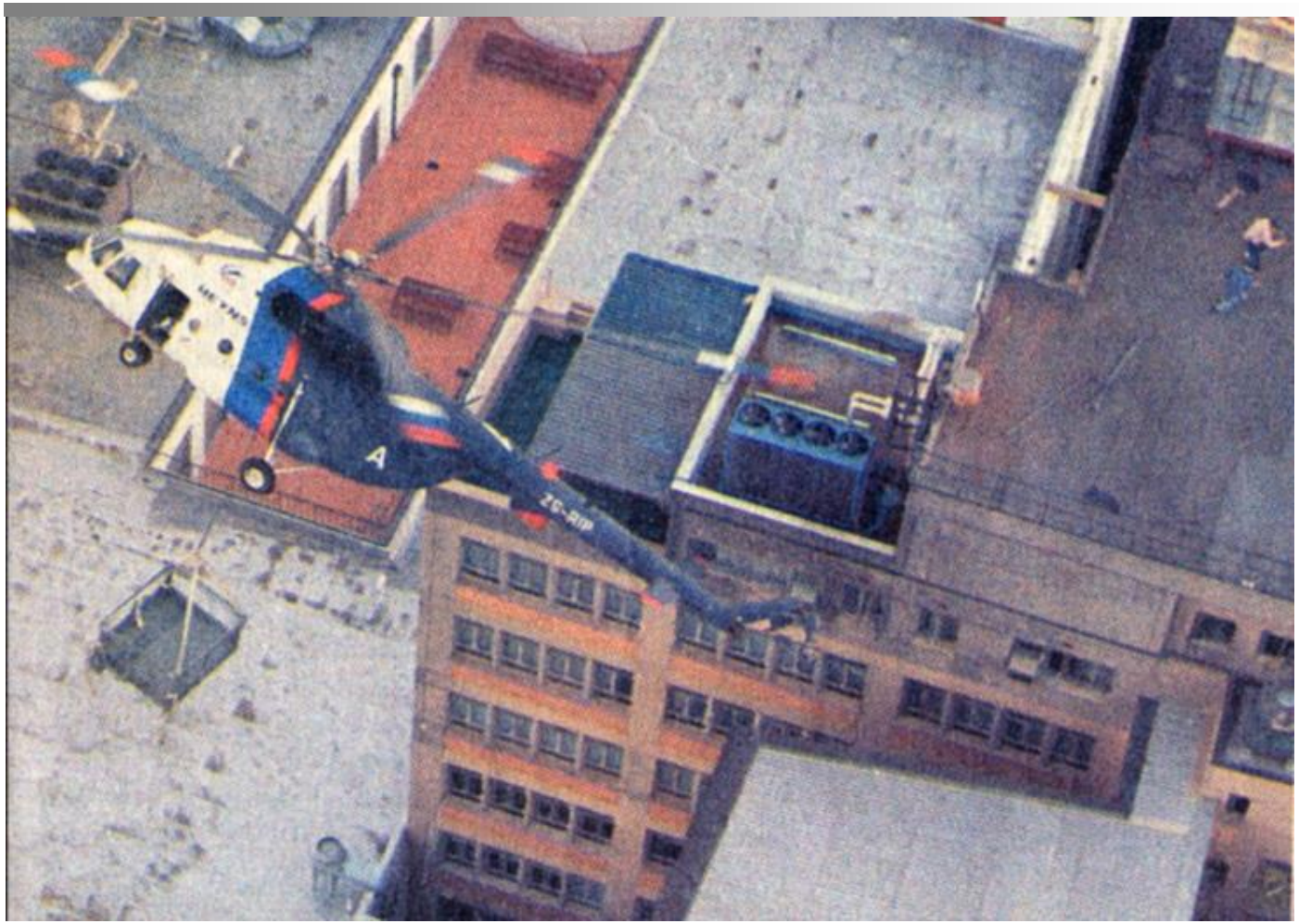
Project initiation and briefing (3)

Bahia Temple, Delhi, India (Smallwood, 2005)

Project initiation and briefing (4)



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

Project initiation and briefing (5)

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

Project initiation and briefing (6)

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

Project initiation and briefing (7)

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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Project initiation and briefing (8)

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

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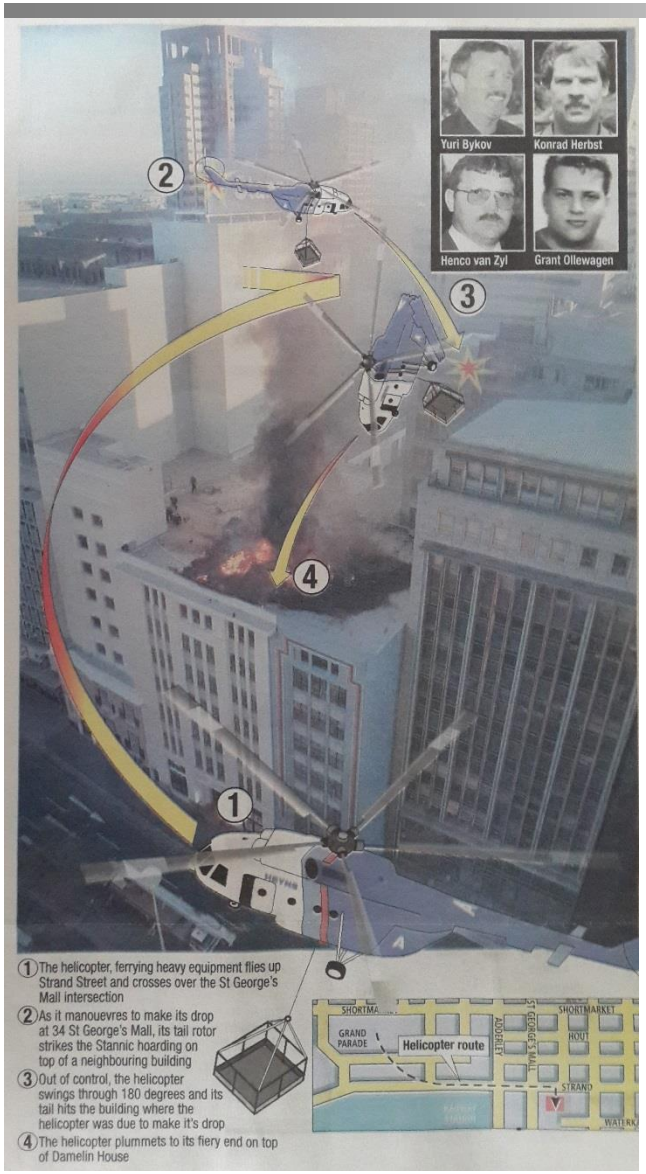
Project initiation and briefing (9)



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

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Project initiation and briefing (10)

- As with all ‘accidents’ (failures of management) this was preventable
- A simple 3-D scan of the neighbourhood would have highlighted the hazards and risks
- Amplifies the role of planning in general, and specifically BRAs, ‘designer’ H&S specifications, ‘designer’ reports, ‘contractor’ H&S specifications, and H&S plans
- Construction is not a ‘Hollywood movie set’!

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Concept and feasibility (1)

- Quality management system (QMS)
- Integrated multi-stakeholder project H&S plans, environmental plans, quality plans, and risk management plans
- Client baseline risk assessment (BRA)
- ‘Designer’ 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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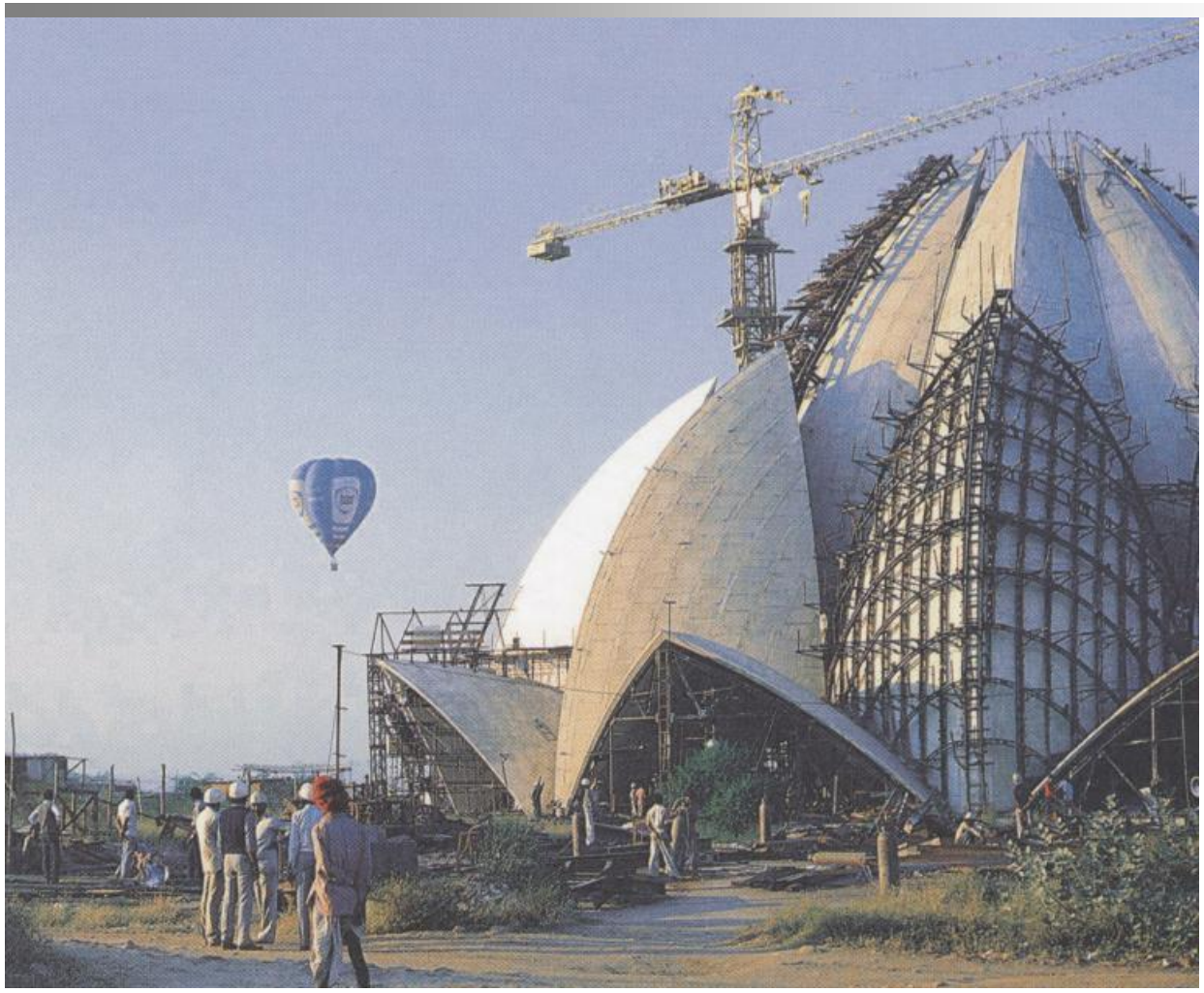
Concept and feasibility (2)



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

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Concept and feasibility (3)

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

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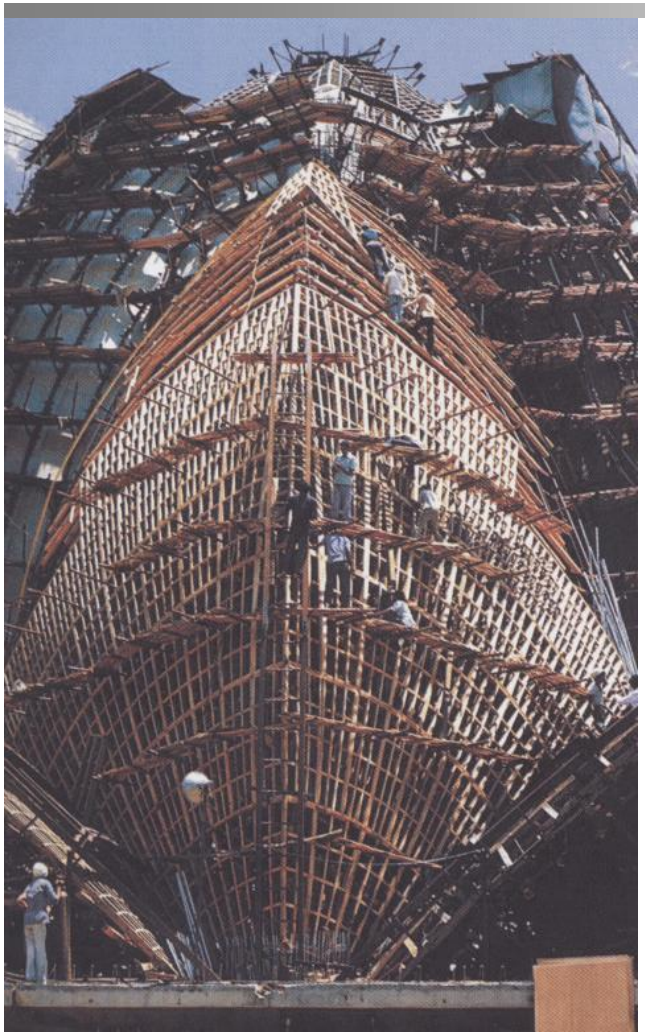
Concept and feasibility (4)



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

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Concept and feasibility (5)

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

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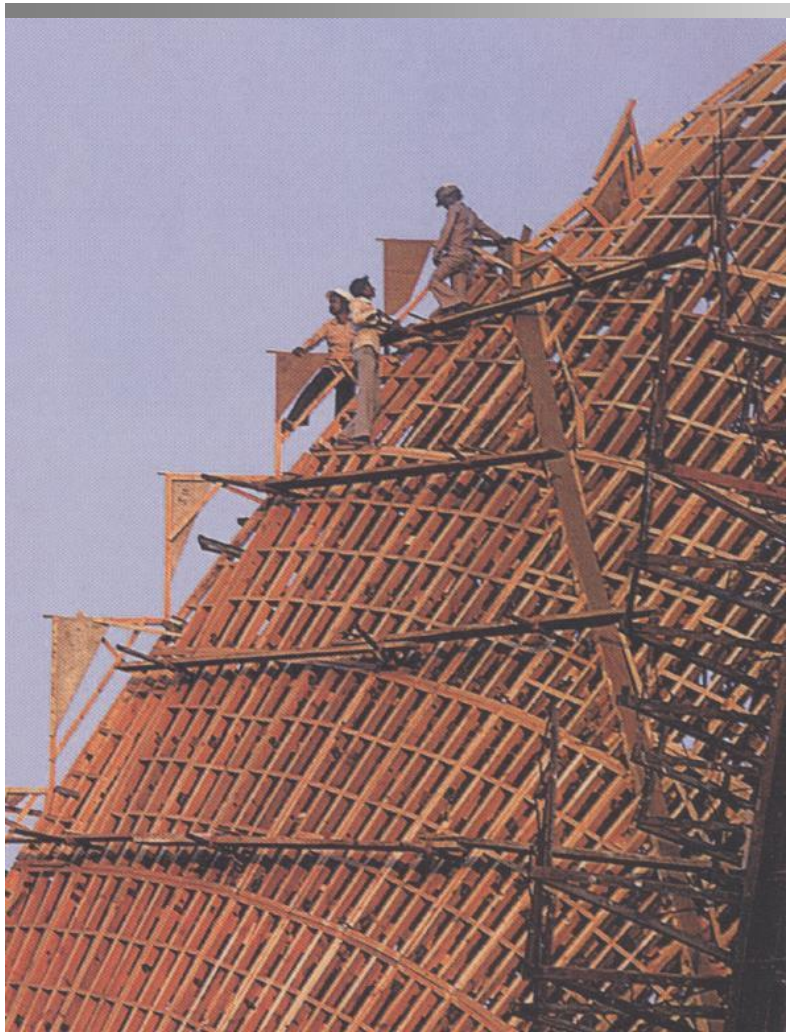
Concept and feasibility (6)



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

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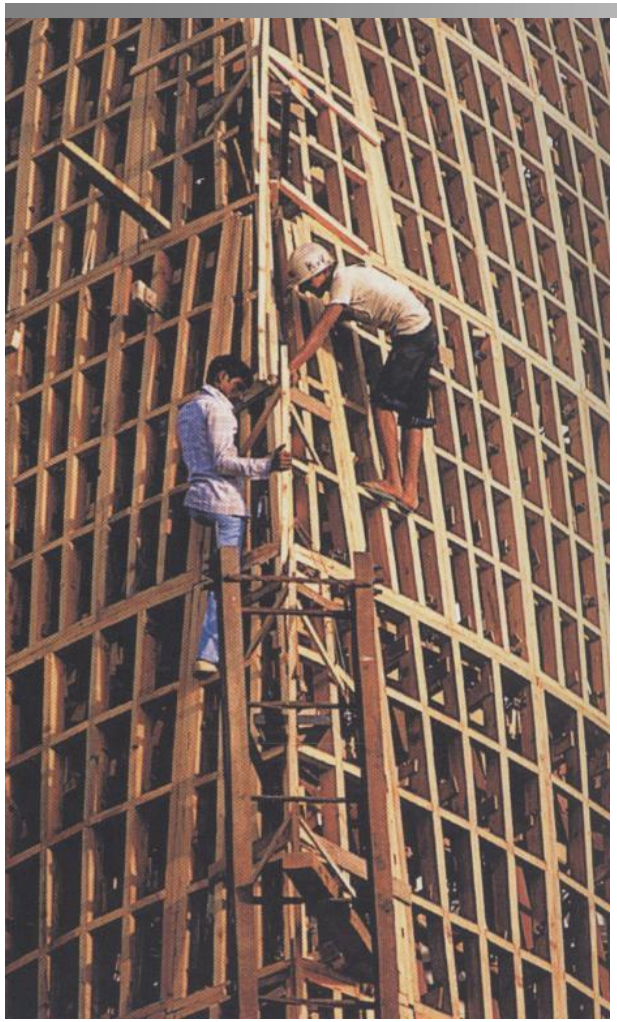
Concept and feasibility (7)



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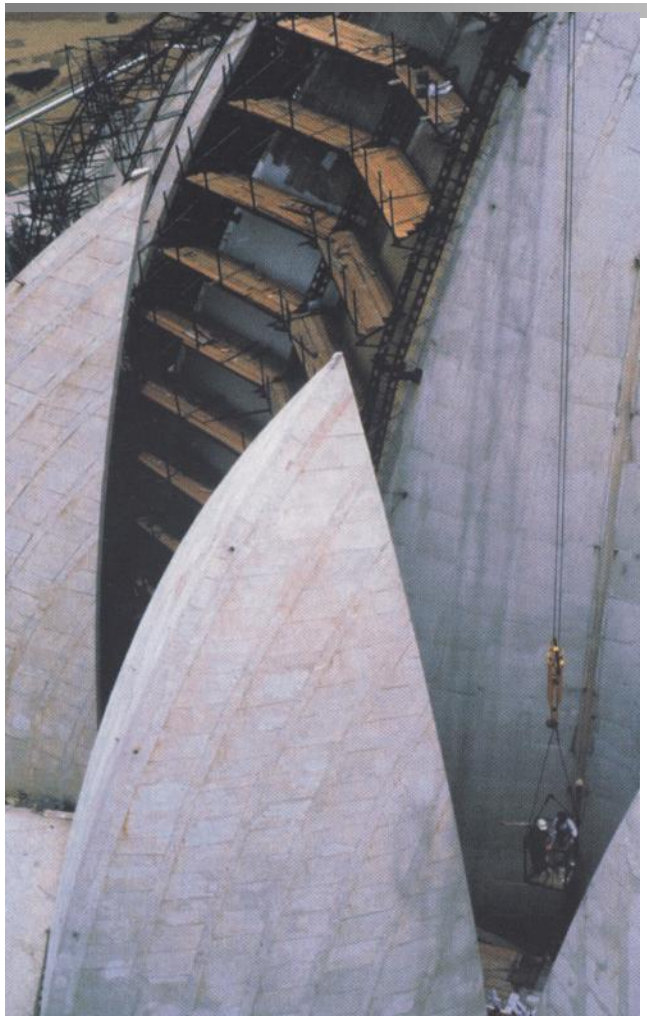
Concept and feasibility (8)



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):
  - Flag residual hazards and risk e.g. heavy concrete blocks, and 1m long precast concrete kerbs
  - For inclusion in tender documentation
- 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)

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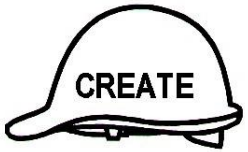
Designing for H&S (4)



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

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 (1)

- Integrated multi-stakeholder project H&S plans, environmental plans, quality plans, and risk management plans
- 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

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Tender documentation and procurement (2)

- H&S measurement – leading versus trailing indicators e.g. percentage of activities for which safe work procedures (SWPs) exist

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Construction documentation and management (1)

- Integrated multi-stakeholder project H&S plans, environmental plans, quality plans, and risk management plans
- Quality management system (QMS)
- H&S management system
- Planning:
  - Programme
  - H&S plan
  - Method statements and SWPs
- Temporary works design
- H&S appointments
- H&S training
- Construction HIRA
- H&S meetings

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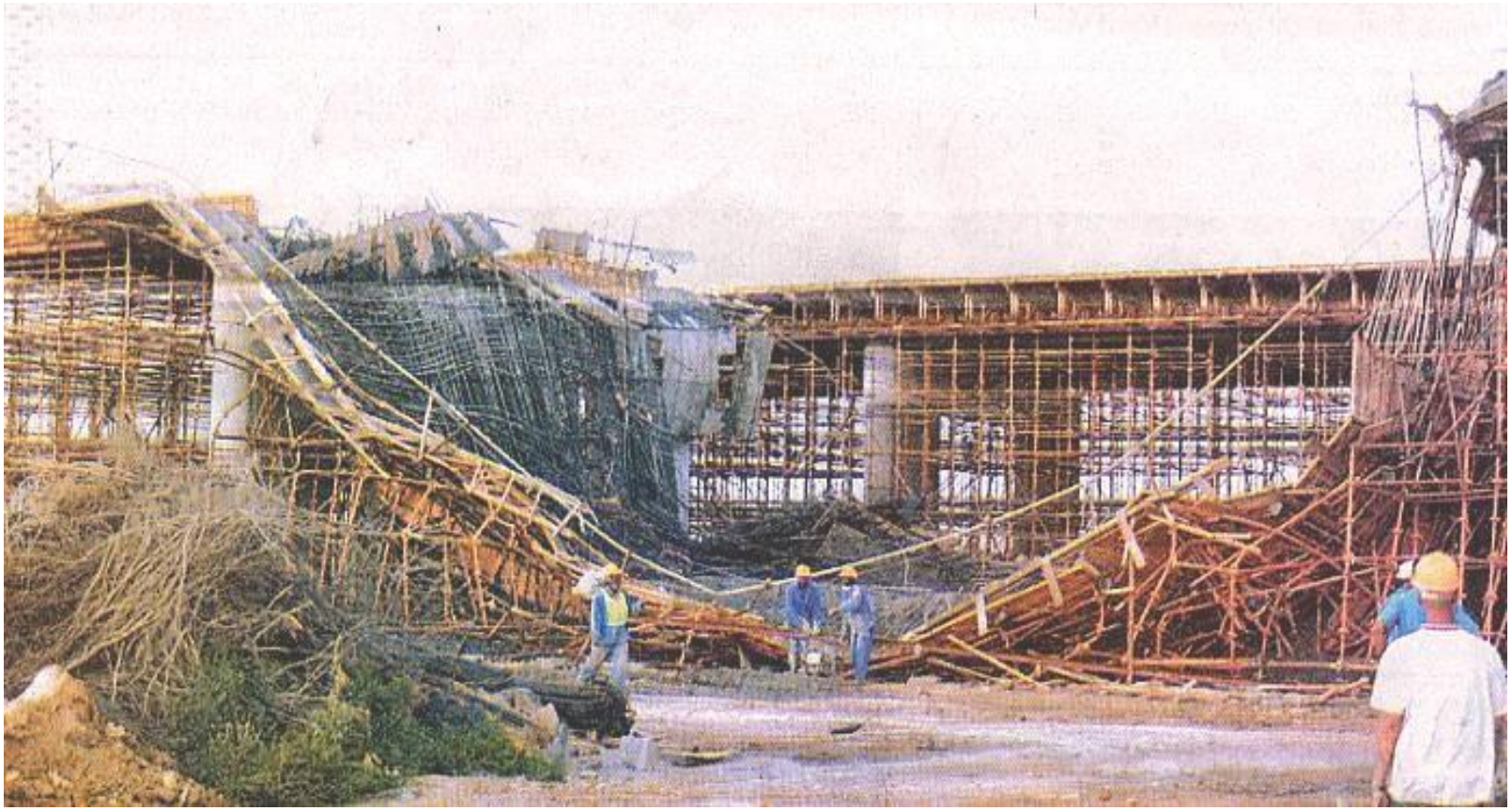
Construction documentation and management (2)

- H&S inspections
- H&S measurement – leading versus trailing indicators

Construction documentation and management (3)

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

Construction documentation and management (4)



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

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Project close out

- Integrated multi-stakeholder project H&S plans, environmental plans, quality plans, and risk management plans
- 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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References to H&S in statutory councils' IOW (1)

Council						
SACPCMP		SACAP	SACLAP	SACQSP	ECSA	SACPVP
CPM (SACPCMP, 2006)	CM (SACPCMP, 2006)	Architects (SACAP, 2015)	Landscape Architects (SACLAP, 2011)	Quantity Surveyors (SACQSP, 2013)	Engineers (ECSA 2013)	Property Valuers (SACPVP, 2011)
Stage 1 Descriptors: Project Initiation and Briefing / Inception / Inception Services						
Nil noted	Not applicable	Nil noted	Nil noted	Nil noted	Nil noted	Nil noted
Stage 2 Descriptors: Concept and Feasibility / Concept and Viability/ Concept and Viability Services						
Advise the client regarding the requirement to appoint an H&S consultant where necessary	Not applicable	Nil noted	Advise the client regarding the appointment of an H&S consultant where necessary	Advise the client regarding the appointment of an H&S consultant where necessary	Advise the client regarding the appointment of am H&S consultant where necessary	Nil Noted
PM (SACPCMP, 2006)	CM (SACPCMP, 2006)	Architects (SACAP, 2015)	Landscape Architects (SACLAP, 2011)	Quantity Surveyors (SACQSP, 2013)	Engineers (ECSA, 2013)	Property Valuers (SACPVP, 2011)
Stage 3 Descriptors: Design and Development / Design Development / Design Development Services						
Facilitate any input from the design consultants required by CM regarding constructability	Review designs by consultants in relation to H&S requirements during construction and provide input if required on related practical and cost issues	Nil noted	Nil noted	Facilitating the input required by the H&S consultant	Facilitate input required by the H&S consultant	Nil noted
Stage 4 Descriptors: Tender Documentation and Procurement / Document and Procurement / Documentation and Procurement Services						
Facilitate and monitor the preparation by the H&S consultant of the H&S Specification for the project	Manage and co-ordinate the preparation and implementation of the H&S requirements for inclusion in the tender	Nil noted	Nil noted	Nil noted	Nil noted	Nil noted

Table 4A: References to H&S in statutory councils' Identity of Work (Deacon, 2016)

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References to H&S in statutory councils' IOW (2)

CPM (SACPCMP, 2006)	CM (SACPCMP, 2006)	Architects (SACAP, 2015)	Landscape Architects (SACLAP, 2011)	Quantity Surveyors (SACQSP, 2013)	Engineers (ECSA, 2013)	Property Valuers (SACPVP, 2011)
Stage 5 Descriptors: Construction Documentation and Management / Construction Contract Administration / Construction / Contract Administration Services						
Monitor the auditing of the contractor's H&S plan by the H&S consultant.	Manage the preparation and agreement of the H&S Plan with the client's H&S consultant and subcontractors	Nil noted	Where the compliance of landscape contractors could be monitored in accordance with the requirements of the H&S consultant	Monitoring preparation and auditing of the contractor's H&S Plan and approval thereof by the H&S consultant	Monitor preparation and auditing of the contractor's H&S Plan and approval thereof by the H&S consultant	Nil noted
Monitor the production of the H&S File by the H&S consultant and contractors	Continuously monitor compliance by site management of the H&S Plan Provide the necessary documentation as required by the H&S consultant for the H&S File					
Stage 6 Descriptors: Project Close Out						
CPM (SACPCMP, 2006)	CM (SACPCMP, 2006)	Architects (SACAP, 2015)	Landscape Architects (SACLAP, 2011)	Quantity Surveyors (SACQSP, 2013)	Engineers (ECSA, 2013)	Property Valuers (SACPVP, 2011)
Manage the finalisation of the H&S File for submission to the client	Manage the finalisation of the H&S File for submission to the H&S consultant	Nil noted	Nil Noted	Nil Noted	Nil Noted	Nil Noted

Table 4B: References to H&S in statutory councils' Identity of Work (Deacon, 2016)

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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 can mitigate
- All accidents are preventable
- ‘Accidents’ = Failure of management
- Reengineer the built environment and construction
- Integrate H&S into all six project stages, plus use and deconstruction stages
- Design for H&S
- Committed and involved clients
- Competent construction project managers, designers, quantity surveyors / cost engineers, and construction managers / supervisors / workers

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Key points (2)

- QMSs
- H&S management systems
- Integrated multi-stakeholder project H&S plans, environmental plans, quality plans, and risk management plans
- Inclusive tertiary built environment education in terms of construction H&S

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