

architecture OTHERWARE
XXV INTERNATIONAL UNION OF ARCHITECTS CONGRESS

DESIGNING FOR CONSTRUCTION HEALTH AND SAFETY (H&S)

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Introduction

- **Design occurs upstream of construction**
- **Designers are a construction industry stakeholder**
- **Designers advise clients**
- **Architectural designers often set the parameters for civil, electrical, interior, landscape, mechanical, and structural designers**
- **Designers have a legal and moral responsibility - legal:**
 - **Section 10, OH&S Act No. 85 of 1993**
 - **2003 and 2014 Construction Regulations**

Importance of the project parameters

Parameter	Architects		Arch. Tech's		Mean	
	Mean Score	Rank	Mean Score	Rank	Mean Score	Rank
Project quality	4.74	1	4.59	1	4.67	1
End-user ergonomics	4.29	3	4.46	3	4.38	2
Environment	4.25	4	4.49	2	4.37	3=
Project cost	4.38	2	4.35	5	4.37	3=
Project time	4.20	5	4.38	4	4.29	5
Project health and safety (H&S)	3.94	6	4.19	6	4.07	6
Construction ergonomics	3.58	4	3.92	7	3.75	7

Table 1: Importance of project parameters to Architectural practices and Architectural Technologists (MS: 1.00 – 5.00) (Smallwood, 2009).

Designing and safety (1)



Natural-light openings, Port Elizabeth (Smallwood)

Designing and safety (2)



'Open' precast concrete cladding, Port Elizabeth (Smallwood)

Designing for safety



'Balustrade' precast concrete cladding, Cape Town (Smallwood)

Designing for ergonomics and H&S (1)



Precast concrete stair flights, Port Elizabeth (Smallwood)

Designing for ergonomics and H&S (2)



Precast concrete stair flights, Port Elizabeth (Smallwood)

Designing and ergonomics and OH



'Bush-hammered' concrete, Port Elizabeth (Smallwood)

Designing for ergonomics and OH



Thermal Lance, Mount Road Police Station, Port Elizabeth (Smallwood, 1987)

Designing and ergonomics



Face brick lining to semi-circular RC soffit, Sandton (Smallwood)

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**

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**

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**

Influence of designers (1)

- **Directly:**
 - **Concept design**
 - **General design**
 - **Choice of structural frame**
 - **Details**
 - **Provision for services (construction ergonomics)**
 - **Specification of materials, finishes and processes**
 - **Consideration of H&S:**
 - **During design coordination**
 - **During constructability reviews**
 - **Reference to H&S:**
 - **During pre-tender site visit**
 - **Upon site handover**
 - **During site visits / inspections**
 - **During site visits / meetings**

Influence of designers (2)

- **Indirectly:**
 - **Selection of / advice regarding type of procurement system**
 - **Selection of / advice regarding preparation of contract documentation**
 - **Decision regarding / advice with respect to project duration**
 - **Status of design upon commencement of construction (contractor pre-planning)**
 - **H&S prequalification of contractors**
 - **Site location e.g. exposure to elements, power lines etc.**
 - **Site coverage e.g. availability for storage**

General design (1)

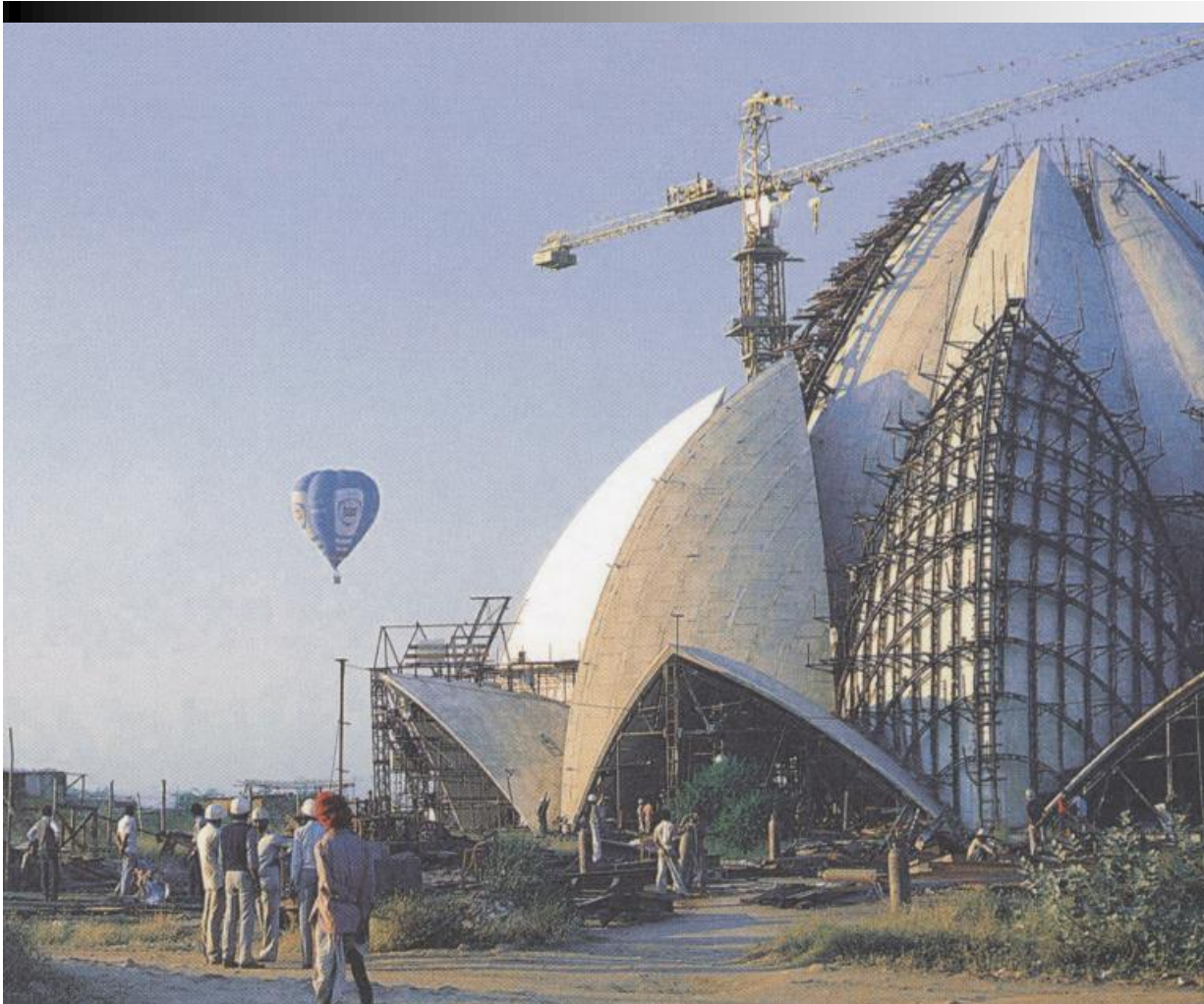
- **Shape of structure i.e. irregular plan shape**
- **Pitch of roof i.e. high pitch**
- **Over sailing sections (access to soffit / working overhead)**
- **External work and finishes (elevated work to facades)**
- **Position of ablutions relative to municipal services (depth of excavations)**
- **Pre-fabrication, pre-assembly and pre-casting:**
 - **Reduces elevated in-situ work**
 - **Reduces manual handling**
 - **Engenders mechanisation**

General design (2)



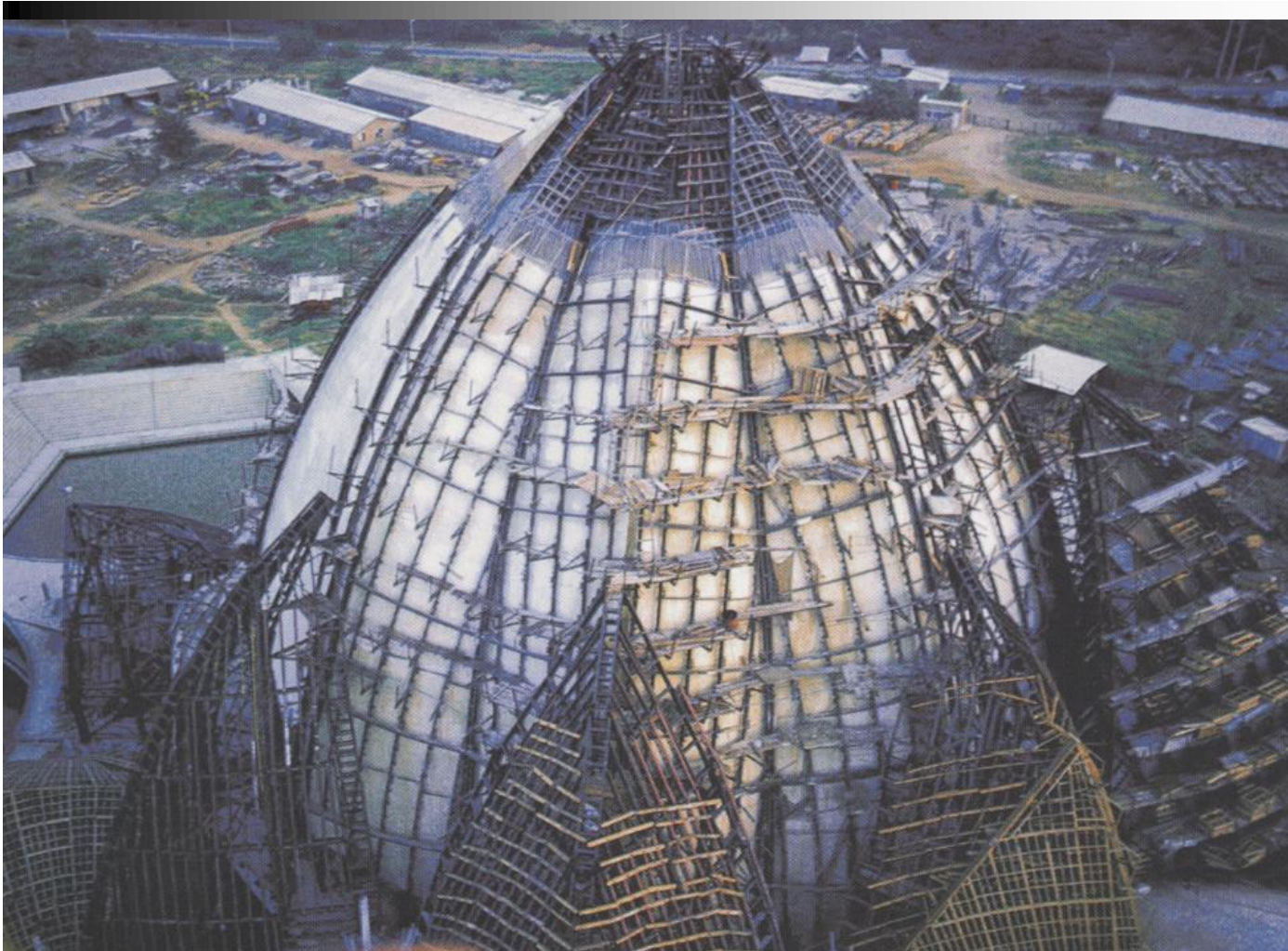
Bahia Temple, Delhi, India (Smallwood, 2005)

General design (3)



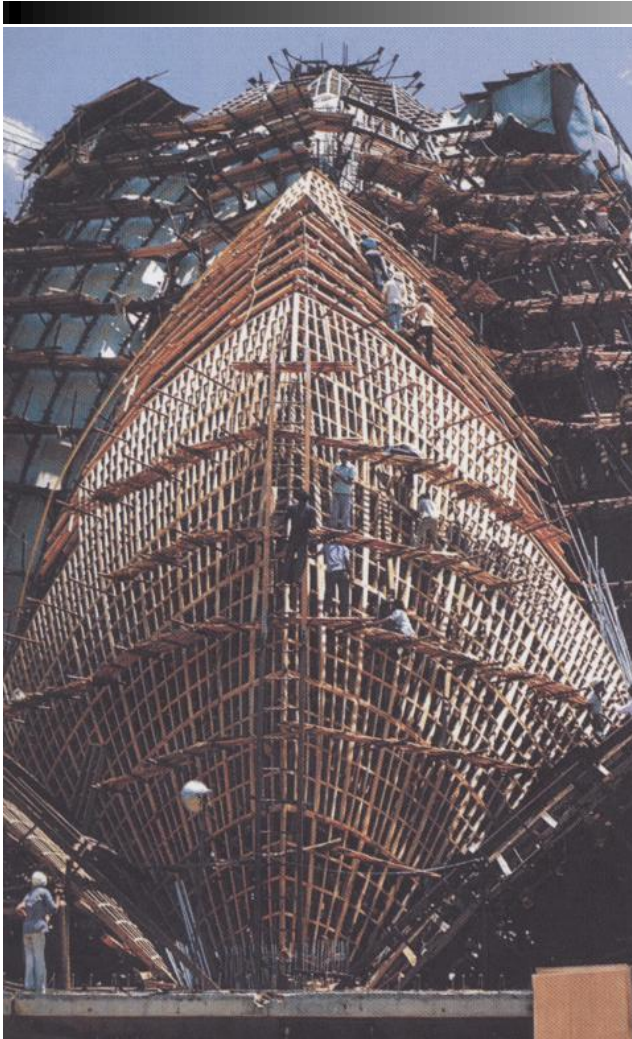
Bahia Temple, Delhi, India (The National Spiritual Assembly of the Bahia'is of India, 2002)

General design (4)



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

General design (5)



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

General design (6)



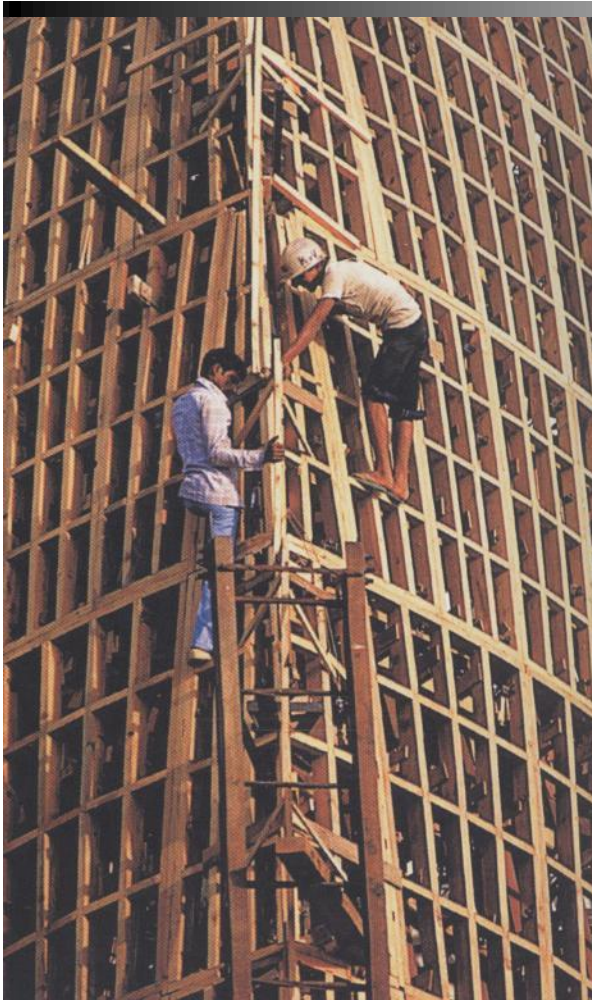
Bahia Temple, Delhi, India (The National Spiritual Assembly of the Bahia's of India, 2002)

General design (7)



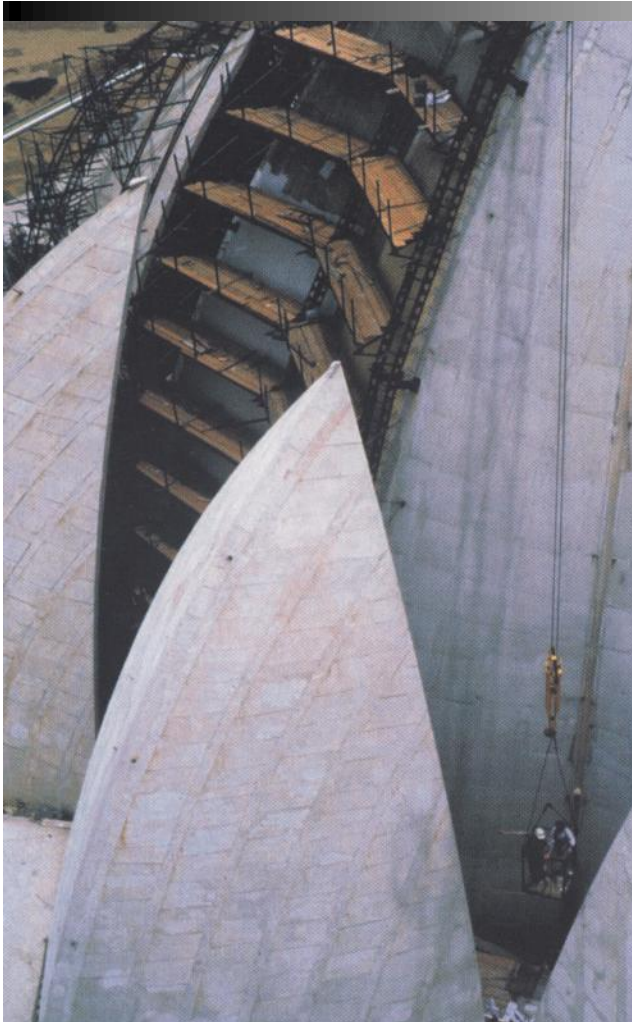
Bahia Temple, Delhi, India (The National Spiritual Assembly of the Bahai's of India, 2002)

General design (8)



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

General design (9)



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

General design (10)



Investec Office Complex scaffolding collapse, Sandton, August, 1997 (Prinsloo, 1997)

General design (11)



Precast wall panels, Dublin (Smallwood, 2004)

General design (12)



Precast floor panels, Dublin (Smallwood, 2004)

Choice of structural frame (1)

- **Load bearing masonry:**
 - **Mass of materials**
 - **Manual handling / Bending and twisting**
 - **On-site storage (housekeeping!)**
- **Timber frame:**
 - **Pre-fabrication**
 - **Light weight**
 - **Less on-site storage = enhanced housekeeping**
 - **Less manual handling**
 - **Engenders mechanisation**

Choice of structural frame (2)

- **Structural steel:**
 - **Less on-site storage = enhanced housekeeping**
 - **Pre-assembly**
 - **Less manual handling**
 - **Very challenging elevated work**

- **Reinforced concrete:**
 - **On-site storage (housekeeping!)**
 - **Manual handling / Bending and twisting / Use of body force**
 - **Challenging elevated work**

Details (1)

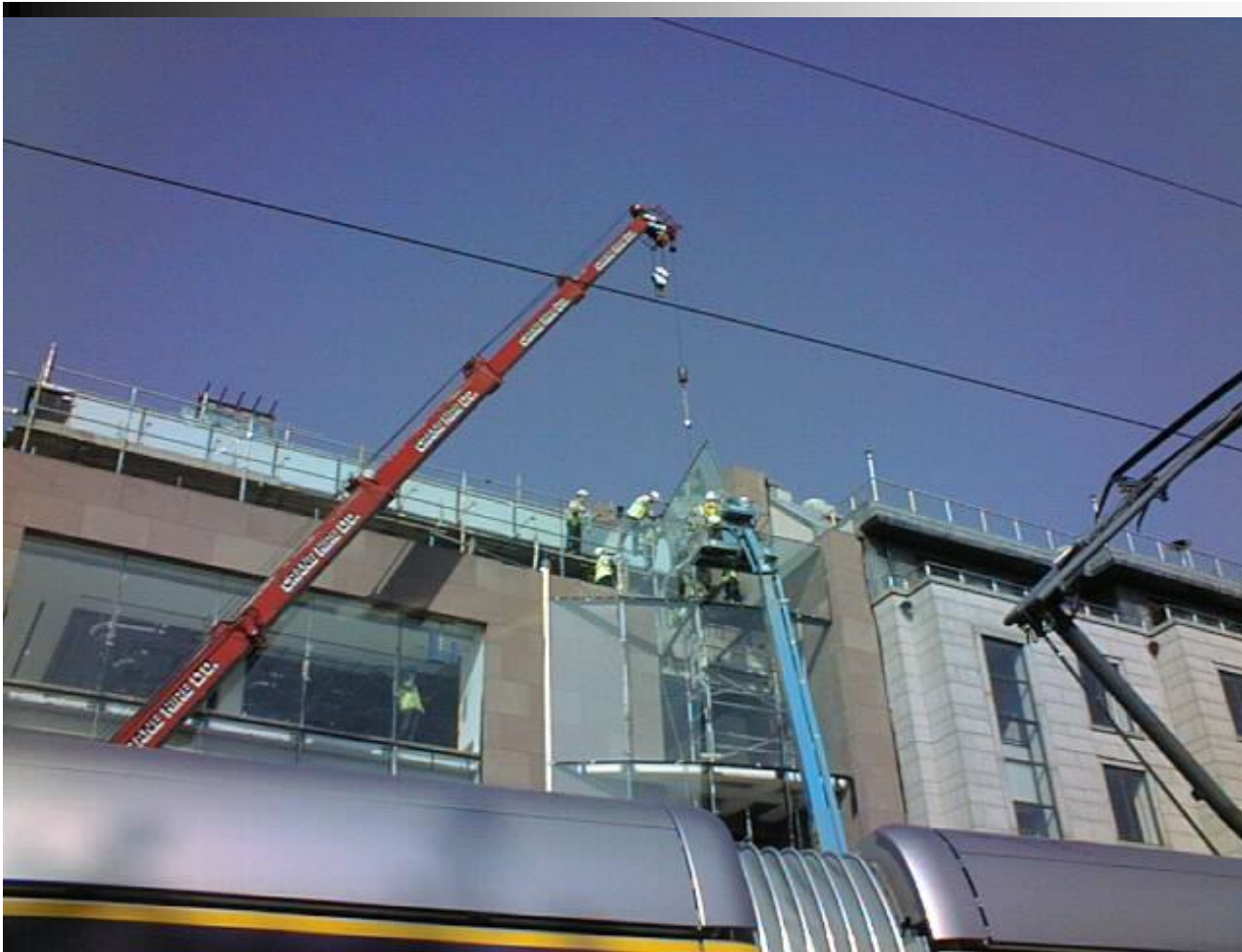
- **Affect constructability**
- **Affect work method**
- **Affect work postures**
- **Affect required plant and equipment**
- **May require access**

Details (2)



Externally installed full fenestration, Dublin (Smallwood, 2004)

Details (3)



Externally installed full fenestration, Dublin (Smallwood, 2004)

Provision for services (1)

- **Affects construction ergonomics:**
 - **No. of services e.g. in ceiling**
 - **Layering (horizontal plane)**
 - **Space for working and fixing e.g. in vertical ducts**
 - **Method of fixing**

- **Therefore, optimum:**
 - **Coordination**
 - **Layering**
 - **Sectional area (vertical ducts)**

Provision for services (2)



Congested ceiling space, Cape Town (Smallwood, 2004)

Provision for services (3)



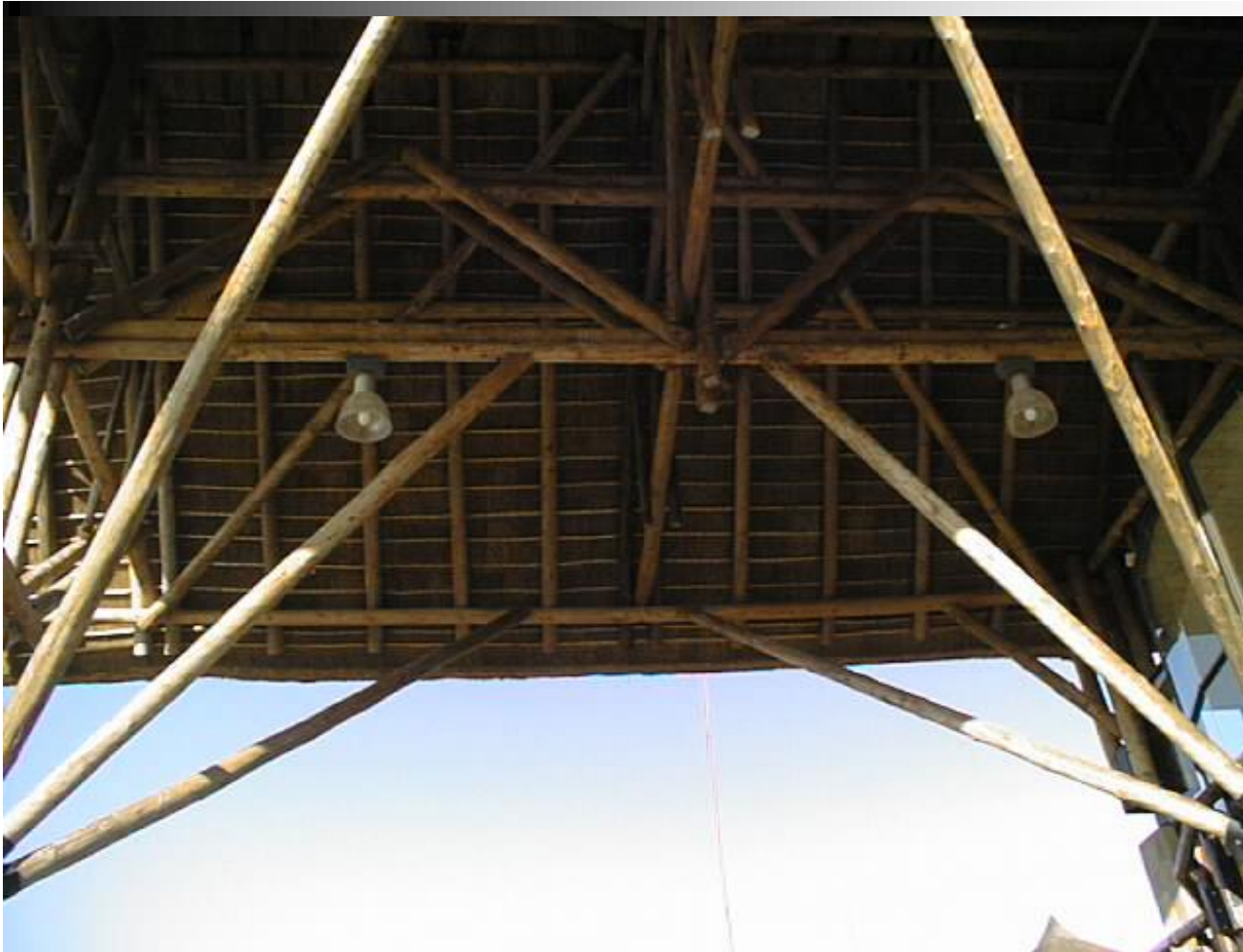
Congested ceiling space, Cape Town (Smallwood, 2004)

Position of fittings (1)



Porte Cochere, Nelspruit Airport (Smallwood, 2004)

Position of fittings (2)



Light fittings, Porte Cochere, Nelspruit Airport (Smallwood, 2004)

Materials (1)

May be / have:

- **Heavy - mass per unit / m / m² / m³**
- **Rough surface**
- **Sharp edges**
- **Toxic**
- **Large e.g. ceiling / drywall panels and glass shop fronts**

Materials (2)



'Melting' mastic asphalt, Canal Walk, Cape Town (Smallwood, 2000)

Impact of design(ers) (1)

Occasion	Response (%)						II	Rank
	Don't know	Never	Rarely	Some-times	Often	Always		
Site inspections/ discussions	0.0	28.3	28.3	28.3	28.3	28.3	2.64	1
Site meetings	0.0	28.3	28.3	28.3	28.3	28.3	2.56	2
Site handover	1.0	28.3	28.3	28.3	28.3	28.3	2.50	3
Preparing project documentation	1.0	28.3	28.3	28.3	28.3	28.3	2.24	4
Pre-tender meeting	1.0	28.3	28.3	28.3	28.3	28.3	2.19	5
Working drawings	1.0	28.3	28.3	28.3	28.3	28.3	2.18	6
Evaluating tenders	2.0	28.3	28.3	28.3	28.3	28.3	2.13	7
Detailed design	1.0	28.3	28.3	28.3	28.3	28.3	2.12	8
Pre-qualifying contractors	1.0	28.3	28.3	28.3	28.3	28.3	2.08	9
Constructability reviews	4.1	28.3	28.3	28.3	28.3	28.3	2.05	10
Design coordination meetings	1.0	28.3	28.3	28.3	28.3	28.3	1.90	11
Client meetings	2.0	28.3	28.3	28.3	28.3	28.3	1.88	12
Concept (design)	1.0	28.3	28.3	28.3	28.3	28.3	1.82	13
Deliberating project duration	4.2	28.3	28.3	28.3	28.3	28.3	1.77	14

Table 2: Frequency at which Architectural practices consider / refer to H&S on various occasions (II: 0 - 4) (Smallwood, 2000).

Impact of design(ers) (2)

Aspect	Response (%)						II	Rank
	Don't know	Never	Rarely	Some-times	Often	Always		
Specification	2.0	26.3	26.3	26.3	26.3	26.3	2.54	1
Method of fixing	1.0	26.3	26.3	26.3	26.3	26.3	2.53	2
Position of components	4.0	26.3	26.3	26.3	26.3	26.3	2.40	3
Edge of materials	4.0	26.3	26.3	26.3	26.3	26.3	2.36	4
Content of materials	2.0	26.3	26.3	26.3	26.3	26.3	2.34	5
Details	3.1	26.3	26.3	26.3	26.3	26.3	2.31	6
Finishes	4.1	26.3	26.3	26.3	26.3	26.3	2.28	7
Type of structural frame	4.0	26.3	26.3	26.3	26.3	26.3	2.26	8
Plan layout	5.1	26.3	26.3	26.3	26.3	26.3	2.22	9
Texture of materials	3.0	26.3	26.3	26.3	26.3	26.3	2.15	10
Design (general)	1.0	26.3	26.3	26.3	26.3	26.3	2.07	11
Schedule	6.2	26.3	26.3	26.3	26.3	26.3	2.03	12
Surface area of materials	6.1	26.3	26.3	26.3	26.3	26.3	2.03	13
Elevations	5.1	26.3	26.3	26.3	26.3	26.3	1.98	14
Site location	3.0	26.3	26.3	26.3	26.3	26.3	1.90	15
Mass of materials	5.1	26.3	26.3	26.3	26.3	26.3	1.87	16

Table 3: Frequency of which Architectural practices consider / refer to H&S relative to various design related aspects (II: 0 - 4)⁴³
(Smallwood, 2000).

Impact of design(ers) (3)

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

Impact of design(ers) (4)

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 5: 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).

Impact of design(ers) (5)

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 6: 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).

Engendering H&S by designers

- **Consideration of H&S throughout all stages of design: brief; concept; detailed design, and working drawings**
- **Pre-fabrication, pre-assembly, and pre-casting**
- **Minimal work at elevated heights**
- **Self-finished materials**
- **Engendering of mechanisation**
- **Appropriate procurement systems**
- **Provision for H&S in contract documentation**
- **Reference to H&S during pre-tender, pre-contract and contract phases of construction, and during commissioning and maintenance phases of projects (and recycling and de-construction)**

Conclusions (1)

- **Designers influence H&S directly and indirectly**
- **Directly through: general design; choice of structural frame; details; method of fixing, and specification of materials and finishes**
- **Indirectly through: selection of procurement system; preparation of contract documentation; decision regarding project duration; pre-qualification of contractors on H&S, and status of design upon commencement of construction**
- **Designers do consider / refer to H&S and ergonomics on various occasions and relative to design aspects:**
 - **Could be the more committed designers**
 - **More so relative to some than others**

Conclusions (2)

- **Designers do understand and appreciate the extent to which various design related aspects impact on construction ergonomics:**
 - **Could be the more committed designers**
 - **More so relative to some than others**
- **Designers can make a major contribution to H&S and ergonomics**
- **Design graduates must be empowered to make such a contribution**

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