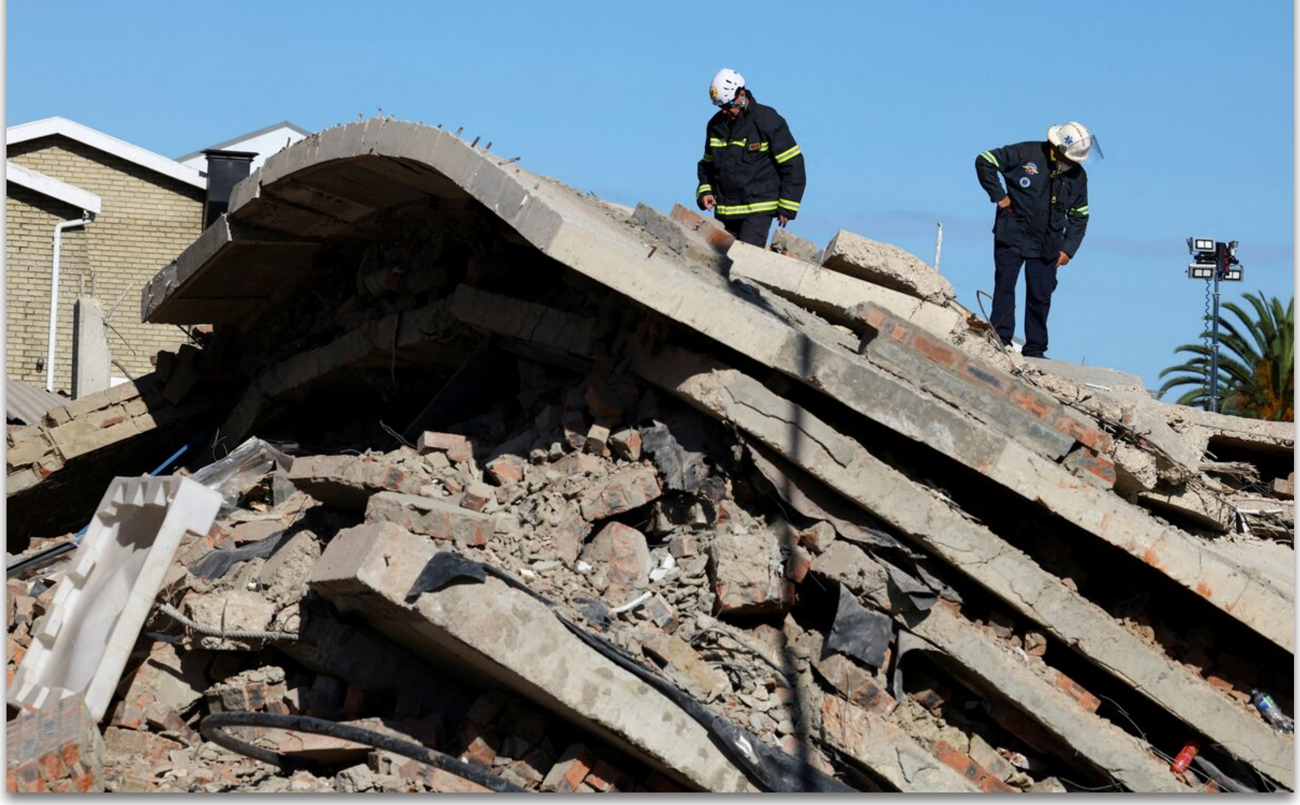
Penny Wise, Pound Foolish

"Careful about small amounts of money but not about large amounts —used especially to describe something that is done to save a small amount of money now but that will cost a large amount of money in the future" - Merriam Webster

Penny Wise, Pound Foolish – A Race to the Bottom

A critique of the construction industry in South Africa

Remnants of the George Building Collapse - 34 Fatalities



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THE 2024 CONSTRUCTION HEALTH AND SAFETY CONFERENCE

ENHANCING CONSTRUCTION HEALTH AND SAFETY

SLIDE 2

What can cause a building under construction to collapse?

The recent incident in George, where a structure under construction collapsed leading to multiple unnecessary fatalities, has raised concerns about the design, management and construction of buildings in South Africa.

An official inquiry for the collapse has not returned a verdict on the likely failure mode so we will avoid discussing the event at George in detail; we will instead examine the potential vectors for building failure.

Possible sources of error leading to building collapse include but are not limited to the following:

@ Design Stage

1. *Lack of Initial Surveys.*
2. *Reduction of Professional Fees.*
3. *Removal of Design Stages.*
4. *Non-adherence to Regulatory Requirements.*

@ Construction Stage

1. *Construction Methodology.*
2. *Lack of Oversight.*
3. *Overloading.*
4. *Material Quality - Fill, Steel & Concrete.*
5. *Structural Defects.*

South Africa has an enviable global reputation for producing innovative engineers and construction methods.

SLIDE 3

Potential Error Pathway @ Design Stage - Surveys

Topographical Survey

- Survey natural and man-made features.
- Map contours, elevations, and slopes of the land.
- Identify buildings, roads, trees, rivers, services, and other significant landmarks.
- Guide design of the project such as ramps, carparks, roads, and utilities.
- Assess site suitability as residential, agricultural, conservation, etc.
- Design drainage & attenuation system to mitigate environmental impact by identifying water flow impacting the site, elevation changes, slope lengths, etc.
- Precise measurements for legal documentation.

Geotechnical Survey

- Assess underground conditions such as soil type and stability, rock formation, and groundwater.
- Determine load-bearing capacities on site and advise on an effective foundation system. Taking into account local vibration and seismic impacts.
- Identify risks such as soft spots, voids, boulders, or contaminated materials.

Ancillary Surveys

1. Traffic Counts
2. Historical Planning Records
3. As-Built Records
4. Verification of existing building properties

Potential Error Pathway @ Design Stage - Extent of Fees

ECSA published gazette advises on professional fees in to:

1. Reduce Risk: Prevent cost-cutting in analysis & design that could lead to public and project risks.

2. Ensure Effectiveness: Promote professional input in projects to avoid wasteful expenditure and ensure high effectiveness.

3. Attract and Retain Talent: An attractive working environment.

4. Control Project Cost: Prevent delay of infrastructure projects due to high costs from designs which have not optimised nor carefully examined.

5. Meet Legislated Standards: Avoiding inadequate engineering leading to high costs and unnecessary HSE risks.

Fees designed to support the development of high-quality infrastructure and development of engineering in South Africa.

- Professionals under pressure to reduce fees to attract work.
- Import of costly construction materials.
- Developer must meet legislated construction and HSE requirements and end user expectations.

Reduction of fees is a **false economy** as with sufficient fees an engineer can create effective cost and time saving measures. Areas for optimisation include but are not limited to:

Building Type | Site Layout | Building Layouts | Material Selection | Programming | Foundation Types | Contracts | Contractor Selection Criteria | Method of Works

SLIDE 5

Potential Error Pathway @ Design Stage - Stages of Design

Six stages, applied globally, to ensure design and construction delivers a comprehensive, efficient, & safe project. Each stage addresses specific aspects of the project.

Stage 1 Concept: Define scope and feasibility. Brainstorm, prelim sketches, consider various design options.

Stage 2 Schematic: Develop approved concept. Engineer & Architect together create a design of the basic structure, layout, functionality, with initial cost estimates & project timelines.

Stage 3 Detail Design: Schematic refined and detailed to construction. Specific materials, systems, & technologies are selected. Ensure all design elements coordinated & integrated effectively.

Stage 4 Procurement: Construction documentation; bill of quantities, tender drawings, contract documentation, site briefing, tender adjudication. Clearly communicate to contractors for pricing and programming of project.

Stage 5 Construction Management: Oversee the project to ensure that the project is built according to design, cost, programme and specification.

Stage 6 Close Out: Snag lists, safety file & as-built drawings, final accounts & certification.

These stages manage the complexity of the project, ensuring each phase is thoroughly planned and executed.

This structured approach minimises risks, controls costs, and ensures the successful completion of the project.

How Errors Can Occur at Design Stage

There are 5No. common areas of human error:

1. Intentional Omission
2. Unintentional Omission
3. Intentional Commission
4. Unintentional Commission
5. Competency

Unintentional errors are the most common mode of failure.

i. Inexperience.

ii. Insufficient resources creating excessive pressure to deliver to budget and programme.

iii. Works are rushed. Critical QC milestones ignored.

iv. Stress can cause logic failure.

The three major factors causing stress for employees are:

1. **Low salaries (56% of employees)**. Attributed to low professional fees.

2. **Long hours (54% of employees)**. Attributed to a lack of sufficiently experienced personnel. Low salaries prevent skilled personnel from being attracted or retained.

3. **Lack of growth opportunities (52% of employees)**. Senior staff have to remain conducting design works rather than taking a more managerial role preventing growth and experience.

In all cases above, correctly determined fees can resolve the issue.

SLIDE 7

Potential Error Pathways @ Construction Stage

1. Construction Methodology

Determine Sequence of Construction, for example:

1. Procurement - Lead times, Alternative Specifications
2. Site Preparation - Phasing, Temp Access, Grading, Site Facilities
3. Civil Works - Excavations, Services, Roads, Foundations, Boundary, Engineered Fill
4. Structural Works - Foundations, Structural Frame, Roof, Enclosure walls, Windows and Doors, Interior Walls
5. Mechanical, Electrical and Plumbing (MEP)
6. Landscaping
7. Final Inspections, Certification and Handover

2. Lack of Oversight

Reduced fees preclude a full time engineer who could effectively inspect the contractor's works, method statements, programme, test results, MSDS, variations, changes from design, variation of specifications etc.

3. Overloading

Tied to the sequence of construction and lack of oversight.

Most buildings will be designed for office or residential loading. Building materials can impose a much heavier load than the structure was designed for initially. Engineer is required to determine whether the proposed method of work is appropriate.

Can only effectively answer if they are comfortable with the design and quality of works conducted.

Potential Error Pathways @ Construction Stage

4. Material Quality

4.1 Steel

Reinforcing (Rebar), structural members, connections and sheeting.

Verification required of steel type, yield strength, dimensions, site arrangements. Impacts cover to rebar, welding, connections, earthing, removing galvanic reactions etc.

4.2 Engineered Fill

Sands, gravels, stone, crusher run, pea gravel, geo-textiles, soilcrete, compaction, bearing capacity, sub surface drainage

To follow the engineer's design to prevent settlement, slippage, rotation, movement etc. Density tests must be returned for each layer.

4.3 Concrete

Blinding concrete, 20-40MPA typical strengths, formwork, cover, vibration, voids, finish, heat, cold, bond breaking, joints, sealant.

Concrete cubes taken and tested for strength, delivery note from concrete truck to verify mix, time to full strength, time to construction access, time to strip formwork, protection from cold and heat, cold joints, scrabbling, bonding, sawcut joints, tied joints etc.

4.4 Non-Exhaustive List of Other Items To be Checked

Insulation | Lighting | Solar | Batteries

Fittings | Fixings | Lighting | Gas

Potential Error Pathways @ Construction Stage

5. Structural Defects

Without Engineer oversight of the construction, it becomes a guessing game as to whether the building is satisfactory.

To confirm a structure after the fact requires extensive works including but not limited to:

1. Excavations at multiple locations to expose foundations and engineered fill for inspection and testing.
2. Density tests of each layer of engineered fill and the compacted formation. Samples to be retrieved for lab tests.
3. Coring of concrete members including foundation, beams and columns to confirm concrete strength and rebar steel specification.
4. Retrieve structural steel samples to confirm material specifications.
5. X-Ray scan of concrete members to verify rebar arrangement and sizes.
6. If necessary, confirm fire rating of materials including plaster, paint, doors, windows etc.
7. Ultrasonic scans to verify thicknesses
8. Visual inspections
9. Survey inspection to verify alignments
10. Placing of strain gauges to determine if there is erroneous subsistence (some subsidence is normal).

The cost of this verification after construction easily exceeds what the initial full design cost would have been.

SLIDE 10

Conclusion

- Most mistakes are non-intentional.
- Material is expensive so professional fees are targeted.
- Legal/ ethical issues when Design & QC not conducted in full.
- Reducing fees is a false economy.
- Higher Installation Cost equates to Lower Operational Costs.
    - Cheaper thermal control of a well insulated building.
    - Subsidence resistant foundations.
- Lower Installation Cost equates to Higher Operation Costs.
    - Expensive thermal control with poor insulation.
    - Foundations cracking due to unknown conditions.

Personal Experience:

Cost: *I have designed industrial plants globally. Sometimes topographic or geotechnical surveys are not conducted. In these cases, we assume the worst case situation for bearing capacities, storm water routes, flooding levels etc and prepare a design that is over-designed in order to protect ourselves from risk of building failure. The cost of this over engineered design exceeds the survey costs by a large factor.*

Design: *Safety audits of road designs. 2No. at design stage and 1No. during construction to identify and remedy HSE issues. In a lot of cases the audits are not always conducted. Evidenced by footpaths leading nowhere, road sign poles in footpath, incorrect timing on robots, lack of kerbs to prevent cutting in of traffic etc.*

Construction Methodology: *A colleague was inspecting the installation of precast staircases in a reinforced concrete tower. A staircase slipped from rigging and landed on an installed staircase which promptly sheared bolts and crushed the personnel below.*