

Paper

Socio-economic responsibilities: the challenge facing structural engineers

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Synopsis

Traditionally, structural engineers have used their skills and expertise to ensure that structures or structural components are serviceable and durable, in addition to possessing adequate strength and stability. However, there is now a need for this traditional role to be broadened and expanded if structural engineers are to contribute towards meeting current socio-economic needs. Definite relationships exist between employment opportunities, available skills, entrepreneurship, and the use of small-scale enterprises in the creation and maintenance of assets. The construction strategies adopted can be used to address social and economic needs and concerns and, depending upon how they are structured, to facilitate the economic empowerment of marginalised sectors of society in a focused manner. Thus, the process of constructing assets can be just as important as the provision of the assets themselves.

This paper examines the employment-generating potential of construction projects; the impact of the choice of technology; targeted procurement and strategies to increase employment opportunities/unit of expenditure; and breakout procurement and mechanisms for engaging marginalised sectors of society in construction projects. It discusses the need for appropriate specifications and technologies and sets out the challenges and

constraints facing structural engineers. It also proposes a possible role which the Institution of Structural Engineers could play in this regard.

Introduction

Traditionally, structural engineers have used their skills and expertise to ensure that structures or structural components are serviceable and durable, in addition to possessing adequate strength and stability. A well-designed structure is, normally, considered to be one that meets these requirements in the most economically efficient manner, least cost being the measure of 'value for money'. Recently, however, the term 'value for money', particularly in developing countries, has been broadened to take cognisance of socio-economic and political benefits. Governments have realised that there is cost to unemployment and poverty and that there is a price to be paid for the economic empowerment of marginalised communities. Accordingly, 'value for money' is now assessed in a revised context.

There are definite relationships between employment opportunities, available skills, entrepreneurship, and the use of small-scale enterprises in the creation and maintenance of assets. The construction strategies adopted can be used to address social and economic needs and concerns and, depending upon how they are structured, to facilitate the economic empowerment of marginalised sectors in a focused manner. Thus, the process of constructing assets can be just as important as the provision of the assets themselves¹.

TABLE 1 – Approximate number of manhours required to manufacture some building and construction materials¹

Item	Description	Unit	Manhours/unit
Aggregate	– sand for mortar, plaster and subbase material	ton	0.12
	– stone for concrete, waterbound macadam; and road bases	ton	0.27
	– transport (20km haul)	ton	0.13
Bitumen	– road grade	ton	0.7
Cement	– OPC	ton	1.1
Clay sewer pipes	– 150mm dia.	100m	68.2
	– 150 × 150 junction	l	0.9
Clay masonry units	– 106 × 212 × 73 (high-tech plant)	1000	3
	– 106 × 212 × 73 (normal plant)	1000	9–9.5
Concrete masonry units	– 140mm hollow (plant manufacture)	10m ²	5.6–8.2
	– 140mm hollow (hand manufacture)	10m ²	22.4
Concrete paving units	– 65mm thick (plant manufacture)	10m ²	3.6–4.1
Concrete pipes	– 450mm dia.	100m	100
	– 600mm dia.	100m	125
Concrete roof tile		10m ²	0.9
Door frames	– standard pressed metal	l	0.5
FC roof sheeting		10m ²	4.1
FC ceiling board		10m ²	1.9
FC sewer pipe	– 150mm dia.	10m	23
Gate valve	– 80–90mm dia. RSV	l	2.0
Glass	– 3mm float	100m ²	4.2
Gypsum ceilings		10m ²	3.3
HDPE pipe	– 32mm dia. (water)	100m	3
Paint	– PVA	100 lit	5
Polyethylene	– pipe grade	ton	3.3
Polypropylene	– pipe grade	ton	5.2
Precast concrete products	– average	ton	7.8
Steel roof sheeting	– 0.6mm galvanised	ton	21.1
Steel sections	– commercial grade angles, channels and IPEs	ton	10.1
Timber	– structural grade	m ³	19.6
uPVC pipes	– 160mm dia. (sewer, HD)	100m	30
Window frames	– ND54	l	1.3
	– NC1	l	0.8

Projects involving the creation of assets can also promote sustainable community development, should they be so structured as to create employment opportunities; promote community involvement; impart technical skills to the unskilled and semi-skilled members of the community; transfer administrative, commercial and managerial skills to the community; retain, as far as is possible, the funds expended on the project within the community; and develop contractors from within the community in which they are to be constructed^{2,3}. Projects that address these objectives allow the resources of the community to be built up in an endogenous manner, i.e. to develop from within.

Recent policy documents in developing countries have sought to explore the development potential of construction projects. For example, the Namibian Government has developed a white paper on labour-based works, the objective of which is to improve living standards in a sustainable way, through increasing income generation and employment opportunities, where technically and economically feasible, for the poor and marginalised sectors of Namibian society in a focused and targeted manner, by way of:

- encouraging the substitution of labour for capital and the use of 'labour-friendly' technologies, thus substituting local resources for imports
- ensuring that Government procurement procedures favour the use of local resources and employment generation
- stimulating and supporting small-scale enterprises to implement labour-based technology
- maintaining the labour absorption characteristics of the various sectors of the economy that already utilise large amounts of labour⁴

The employment potential of construction projects

In a report commissioned in 1994 by the National Housing Forum in South Africa, Watermeyer & Band¹ suggested that there are a number of ways in which employment opportunities in the provision of housing and related infrastructure can be maximised; these relate to forms of construction, construction methods, and manufacturing methods. They recognised that, in order to achieve the goal of maximising employment opportunities, quantitative information needed to be made available to developers, architects, engineers, and the like, as to which technologies, construction methods, materials, etc., would be likely to promote high employment.

Employment opportunities in the construction of the built environment (i.e. houses, amenities, and infrastructure) were examined in some detail in this National Housing Forum study. Manufacturers and producers of a wide range of construction materials were approached to provide information regarding the number of manhours required to produce their products. It

TABLE 2 – Comparison of the number of manhours required to construct non-masonry and masonry houses¹

Construction type	Number of manhours (non-masonry)			Number of manhours for equivalent masonry houses		
	Materials	Site labour	Total	Materials	Site labour	Total
Timber (SALMA)	300	1180	1480	200	1700	1900
Precast concrete panels and posts (Blitz)	150	210	360	120	1120	1240
Steel frame with 110mm brick infill panels (Belaton)	330	880	1210	160	1400	1560

TABLE 3 – Evaluation of non-masonry house types¹

Construction type	Estimated costs (1994) (Rand)		Cost/manhour (Rand/manhour)	
	Non-masonry	Masonry equivalent	Non-masonry	Masonry equivalent
Timber (SALMA)	47 200	46 100	32	24
Precast concrete panels and posts (Blitz)	16 000	20 300	44	16
Steel frame with 110mm brick infill panels (Belaton)	28 400	30 800	23	20

TABLE 4 – Manhours required in the provision of infrastructure for a low-cost township using conventional construction methods¹

Service	Estimated manhours (%)		Estimated total number of manhours/plot	Cost/manhour (Rand/manhour) (March 1992)
	Materials manufacture	Site labour		
Water	13	87	39	20
Sewerage	16	84	43	14
Roads (low standard)	14	86	21	36
Stormwater	8	92	26	16
Electricity	70	30	117	20

TABLE 5 – Provision of water and sewer reticulation in a housing development using employment-initiative methods of construction¹

Service	Labour manhours/plot (March 1992)		(Rand/manhour)	
	Plant-based	Labour-based	Plant-based	Labour-based
Water	39	58	20	14
Sewerage	43	72	14	9

appeared logical that this figure should include all the time spent on obtaining raw materials, manufacturing the item and stockpiling it prior to distribution, and could be based on the total number of manhours worked in the industry (management, administrative staff, workers, etc.) and the quantity of the item produced. Some of the results of this survey are summarised in Table 1. Using the CSIR Division of Building Technology's housing delivery systems analysis (HDSA) database, Watermeyer & Band were able to estimate the number of manhours required to construct a masonry house for any given floor plan. In this manner, they were able to compare the total number of manhours required to construct houses using different forms of construction (see Table 2). They suggested that employment opportunities should be linked to cost to ensure that sector effectiveness and efficiency were not impaired. Table 3 compares the cost/manhour for the different forms of house construction presented in Table 2.

Watermeyer & Band demonstrated how similar statistics could be generated for the provision of township services. Table 4 presents such statistics for the servicing of stands in a specific low-cost housing development in South Africa (typical electrification costs are included for comparative purposes). Manhours associated with the excavation of trenches using labour-based construction methods, based on statistics derived from Soweto's Contractor Development Programme, were then substituted for those associated with plant-based construction. The implications of using these construction methods are reflected in Table 5.

In 1995, Watermeyer *et al*⁵ proposed a procedure to appraise opportunities presented by construction projects. The procedure examined two types of opportunities, i.e. employment and community opportunities. Opportunities in each category were examined in detail and optimised before being combined in a simple formula to index their contributions and to permit comparisons with other projects to be made.

In essence, this approach examined and evaluated the following:

- the multiplier in employment opportunities
- expenditure/unit of employment generated
- the amount of construction cost retained by the community
- the cost of the proposed construction compared with that using conventional construction practices
- the quality of the end product compared with that produced using conventional construction techniques

The approach presupposes that the desirability of a project has been established; it does not replace conventional methods of appraising projects, e.g. cost-benefit analysis, and focuses on the choice of construction methods, technologies, and practices, and the structuring of construction contracts⁶.

An analysis of Soweto's Contractor Development Programme^{5,6} (a programme embracing labour-intensive methods and labour-based technologies and training and encouraging the community to participate in the manage-

TABLE 6 – Estimated number of manhours generated in Soweto's CDP⁵

Type of construction	Unit	Estimated number of manhours/unit			
		Materials	Site labour	Manage-ment	Total
Road construction (waterbound macadam + stormwater)	m ²	0.5	6.8	1.8	9.1
Road construction (concrete block paving + stormwater)	m ²	0.7	8.0	1.8	10.5
Secondary water mains	m	0.4	5.9	0.9	8.2
House connection	plot	0.6	31.4	6.0	38.0

TABLE 7 – Expenditure/unit of employment generated in Soweto's CDP⁵

Type of construction	Estimated expenditure/manhour (Rand)
Road construction (waterbound macadam)	17.9
Road construction (concrete block paving)	18.4
Secondary water mains	17.4
House connections	17.1

TABLE 8 – Percentage of construction cost retained by the community in Soweto's CDP⁵

Description	Road construction	Secondary water mains	House connections (plumbing)
Labour contract	26	22	33
Transport	2	8	9
Materials management	2	3	2
Construction management	7	6	6
Total	37	39	50

rial, commercial and administrative aspects of construction) revealed some interesting statistics, some of which are set out in Tables 6–8. The programme generated employment at a cost of approximately R18/manhour, whereas the average cost for the civil engineering industry in South Africa amounted to approximately R37.50/manhour.

An examination of Tables 3–7 indicates that the choice of technology has a marked influence on the number and location of employment: e.g. a masonry house may generate 3.5 times more manhours of employment than an equivalent precast concrete house; the same precast concrete house may, however, generate 1.25 times more manhours of employment in the manufacture of materials than the masonry equivalent.

The choice of construction method (particularly in the case of civil engineering projects) can significantly influence the total number of manhours of employment generated. The construction of conventional masonry housing units, depending upon the standards adopted, realises approximately 50% more employment opportunities/unit of expenditure than plant-based servicing of sites. If, however, sites are serviced using labour-based construction practices, without increasing the total construction cost, this is 50% more effective than the construction of masonry housing units in creating employment opportunities.

The choice of manufacturing method of construction components can also significantly affect the number of employment opportunities generated: e.g. the ratio of manhours employment generated in conventional construction on-site to that generated in the conventional off-site manufacture of the associated materials is 9:1 for house construction and 6.5:1 for township services (roads, stormwater drainage, water supply and sewerage). There is, clearly, considerable scope for increasing employment opportunities through the use of employment-intensive methods of manufacture of materials.

Changes in methods and technologies that increase the labour content of construction and the manufacture of materials can yield great increases in the number of employment opportunities generated/unit of expenditure. This would require large, well-established companies to change their work

methods and reduce their reliance on capital-intensive technologies: a difficult task. In contrast, small-scale enterprises (which, being small, have limited access to capital and invariably operate and conduct their businesses in a more employment-intensive fashion and favour light-equipment-based forms of construction⁷) would have little difficulty in adopting new methods and technologies.

Recent research in South Africa has indicated that, provided there is little or no cost premium associated with employment-intensive practices, the overall increase in employment opportunities for a given project over conventional plant-based practices may reach a factor of 2 in urban infrastructure and 3 in rural road construction: increases that are extremely valuable⁸.

The impact of the choice of technology

The choice of technology not only influences employment parameters, as previously described, but determines who is able to participate in a project. The following two examples of the impact of technology choices illustrate this.

In the first example, a church community wished to construct a ± 600m² church hall on a site where moderately expansive clays were present. A member of the congregation, who had recently been made redundant, volunteered to construct the building on a labour-only basis. He had some building experience and had access to some bricklayers and a small truck and trailer. In addition, he had the necessary commercial credibility to hire any minor equipment he required.

The builder did not, however, have access to carpenters capable of constructing forms for reinforced concrete work, nor did he own any formwork or have the experience to supervise reinforced concrete works. So, if the hall had been designed as a reinforced concrete framed building, he could not have constructed it and the church would have had to look outside their congregation for someone to construct the hall.

To accommodate the builder, the hall was designed as a reinforced masonry structure. Reinforcement was placed in masonry columns and bedjoints and fabric reinforcement in cavity walls. Using this form of construction, no formwork was required, and the builder was able to use his bricklayers to construct the entire structure. The form of construction proved to be very cost effective, particularly in view of the founding conditions.

In the second example, a rural community was allocated funds for the construction of school classrooms and toilet blocks, the intention being that the community, with appropriate management and technical support, would itself undertake the construction. Most of the structures were located on expansive clay, and total surface movements of approximately 50mm were predicted. Typically, structures built on sites of this nature in South Africa are founded on stiffened, reinforced concrete rafts or on piles. The community simply did not have the skills necessary for these forms of construction.

Alternative solutions were sought. A cellular raft (Boucell, i.e. a foundation system that comprises two horizontal fabric-reinforced slabs interconnected by a series of web beams) was finally decided upon. This system did present a few construction challenges that required some innovation to overcome. Old tyres obtained at no cost, filled with soil, were used as void formers. Masonry was used to create a perimeter beam. (As the width of an average tyre is 170mm, this solution enabled a course height of 85mm to be maintained in the structure.) The space at the centre of four adjoining tyres proved ample for the placing of shear links. The rafts were readily and economically constructed by the community.

Sometimes it is more appropriate to look to old technologies rather than to attempt to optimise current ones. In Zimbabwe and South Africa, rubble masonry (an old technology investigated by 19th century engineers) has been resurrected⁹. Rubble masonry is a building material comprising uncut stones bound together with cementitious mortar. Several small dams and bridges have been constructed recently at considerably lower costs than conventional alternative designs^{9,10}. Rankine suggests that the advantages of using this employment-intensive technology, instead of conventional alternatives, include the following⁹:

- (1) The only material purchased is cement.
- (2) The acquisition costs of sand and stone, sourced in close proximity to the site, are limited to wages for the gatherers and any blasting of rock that may be necessary.
- (3) Transportation costs are minimised, as cement, which accounts for approximately 7% of the mass of the rubble masonry structure, is the only material that is hauled any significant distance.
- (4) Rubble masonry requires no vertical formwork to contain it during placement.

This technology has not only increased employment opportunities/unit of expenditure, but has also afforded access to employment opportunities to unskilled people living in close proximity to the projects.

Achieving socio-economic objectives through construction projects

The attainment of socio-economic objectives through construction projects is invariably linked to economic activity that may be initiated by the private sector, the public sector, or a community. Funding for such activity may come from various sources. The private sector may use its own funds should it, for business reasons or in pursuance of a social responsibility programme, elect to adopt socio-economic objectives on a project. In some instances, Governments may offer incentives, such as taxbreaks, to encourage the private sector to embrace certain socio-economic objectives in their capital works programmes. Any taxbreaks offered, however, invariably lead to a loss in Government revenue and necessitate expenditure to ensure that the conditions surrounding the schemes are met. Governments, on the other hand, may set out to embrace socio-economic objectives in a direct manner on some or all of its publicly-funded capital works projects or may provide seed capital to communities to embark upon projects.

The approach over the past few decades in achieving socio-economic objectives through construction projects in developing countries has been to establish special programmes: e.g. the International Labour Organisation and the World Bank have been involved, since 1970, in employment programmes for rural road construction which have sought to substitute labour for plant in a cost-effective manner.

Special programmes have only a relatively small impact on the economy as a whole. Expenditure on such programmes is usually only a small fraction of public sector expenditure on engineering and construction projects. Public sector procurement, however, if used as an instrument of policy, can, because of its size, impinge significantly on the economy as a whole: e.g. procurement by public bodies and nationalised industries in the United Kingdom in 1984 was found to account for approximately 22% of gross domestic product¹¹. For this reason, public sector procurement has been used in developed countries to achieve certain social policy objectives, such as the creation of jobs, the promotion of fair labour conditions, the use of local labour, the prevention of discrimination against minority groups, the improvement of environmental quality, the encouragement of equality of opportunity between men and women, and the increased utilisation of the disabled¹².

All too often, the beneficial effects of policies that are promoted through procurement is doubtful or minimal: e.g. the European Commission estimated that regional preference schemes in the United Kingdom applied to only 0.02% of Government procurement and that there was no evidence that it had made a significant contribution in attaining the objectives¹¹. Even where benefits can be achieved, they must be weighed against the cost of so doing through procurement, in terms of either a price premium or a compromise on other matters such as time or quality. Enforcement costs must also be considered.

What has been needed is a cost-effective procurement system which provides, encourages and promotes a Government's socio-economic objectives in a definable, quantifiable, measurable, verifiable and auditable

manner, within a fair, equitable, competitive, cost-effective and transparent environment, without¹³:

- over-taxing the administrative capacity of Government
- creating unfair competition within sectors of the economy
- abusing or lowering labour standards
- exposing the Government to unacceptable risks
- compromising value for money
- compromising the efficiency and effectiveness of the private sector in its ability to deliver

Recently, a system of procurement that meets the aforementioned requirements has been developed in South Africa¹³. This system, known as 'targeted procurement', enables procurement to be readily used as an instrument of policy by public bodies, both on a large scale and in a focused manner. Aspects of targeted procurement can also be used to measure, quantify, verify and audit any socio-economic targets that are to be met. This is important where Governments grant concessions, linked to socio-economic objectives, to the private sector.

Targeted procurement

Overview

Targeted procurement^{7,8,13} (an innovative form of procurement developed recently in South Africa to provide employment and business opportunities for marginalised individuals and communities) enables social objectives to be linked to procurement in a fair, transparent, equitable, competitive and cost-effective manner. Targeted procurement also permits these social objectives to be quantified, measured, verified, and audited.

Targeted procurement, through a variety of techniques, provides opportunities for participation by targeted enterprises, even those who may not have all the necessary resources, capacity or expertise to perform contracts in their own right. This is done in a manner that does not guarantee contracts to such enterprises. On small contracts having a value below a predetermined financial threshold, direct preferences are accorded to targeted enterprises to tip the scales in their favour; on contracts above a financial threshold, tenderers are required to compete on the basis of both product and process. Technical specifications are used to define the product and to set out the acceptance criteria relating thereto. Standardised resource specifications are used to define social objectives and the related acceptance criteria. These specifications accordingly define the social deliverables that are to be realised through the process of delivery and set out the manner in which they can be achieved, measured, and monitored. Contracts are usually awarded to the most advantageous offer, based on a balance between the tendered price and the tendered deliverables in respect of targeted groups. Targeted enterprises, depending upon the contracting strategy adopted, may participate in contracts as prime contractors, joint venture partners, subcontractors, service providers or suppliers.

A 90/10 formulation for the tender adjudication mechanism is usually employed, 90 points being for price and 10 points for development objectives (process). This restricts the theoretical cost premium to a maximum of approximately 11%. (In South Africa, this formulation has been found to achieve very satisfying socio-economic results, the average cost premium paid on works contracts being less than 1%^{8,13}. Further particulars may be

TABLE 9 – Standard targeting strategies: engineering and construction works contracts¹⁴

Contract		Targeting options	
Type	Class	Target groups	Resource specification
Prime	International	Nil	
Prime	Major	● Affirmable Business Enterprises ● Local resources (i.e. local enterprises, manufacturers and labour) ● Increase in number of person hours employment generated/unit of expenditure ● Local/marginalised labour	Targeting of Affirmable Enterprises (TPI). Targeting of Local Resources (TP4). Engagement of Targeted Labour (TP5).
Prime	Minor	● Affirmable Business Enterprises	—
Prime	Micro	● Affirmable Business Enterprises	—
Structured joint venture	—	● Affirmable Business Enterprises ● Specific marginalised enterprises	Structured joint ventures (Affirmable Partners) (TP2). Structured joint ventures (Targeted Partners) (TP3).
Development	—	● Fledgling/embryonic enterprises or aspirant entrepreneurs who do not have the capabilities or resources to contract as prime contractors.	Provision of construction and materials management services, as appropriate.

found on the Department of Public Work's website www.pwdprocure.co.za.)

Small and medium enterprises can be targeted on either a generic or area-bound (localised) basis. Generic targeting, in turn, can target either all small and medium enterprises within a country, or block of countries, or small and medium enterprises within demarcated political boundaries which are owned and controlled by marginalised individuals (Affirmable Business Enterprises); marginalised individuals can be defined on the basis of race, gender, ethnicity, disability, etc.

Labour can be targeted on the basis of gender, race, ethnicity, locality, age, disability, period of unemployment, etc. Even ex-combatants could be defined as the target group. Unskilled/semiskilled labour can be targeted on the basis of wage levels, and the increase in employment opportunities/unit of expenditure can be readily measured, should targeted labour be defined on this basis.

The standard targeting strategies for traditional preplanned works contracts are set out in Table 9¹³. The options presented cater for the range of target groups typically encountered. Some of the strategies presented may be employed on other forms of contract, e.g. design and build; develop and construct; design, build, operate and finance; or cost reimbursable¹⁴.

Increasing employment opportunities/unit of expenditure

The choice of technology is generally made during the basic design phase of a works contract, whereas the choice of construction method/methods of materials manufacture is usually decided upon during the implementation phase. Two alternative procurement approaches to implementing employment-intensive works methods can be adopted.

Method 1: Lay down the use of specific employment-intensive technologies and methods of construction/manufacture in the tender document.

Method 2: Afford tenderers the opportunity to choose the technology/construction method/method of materials manufacture they wish to use in order to implement employment-intensive methods.

Either method may be used to increase the quantity of employment generated/unit of expenditure. Method 1 usually achieves the objective of restricting the use of certain types of plant/manufacturing method by specifying particular technologies. The economic viability of this approach is, however, dependent on the ability of the designer/specifier to forecast cost. Method 2, on the other hand, by means of development objective/price mechanisms and resource specifications, enables tenderers to tender the amounts of targeted labour they undertake to engage in the performance of the contract. Any potential price premium can, as such, be readily assessed during the adjudication of tenders. Method 2 therefore has the distinct advantage that tender prices will usually fall within acceptable limits, and the economic justification of decisions relating to employment generation will not be necessary.

Unbundling strategies (breakout procurement)

Small and medium enterprises (SMEs) can participate in public sector procurement in one of two ways: they can either contract directly with a public body or participate as a subcontractor, supplier or service provider to a prime contractor in the delivery chain. The breaking down of tenders into smaller components to afford SMEs access to procurement opportunities is not always justifiable owing to the division of responsibilities, interdependence of activities, programming, duplication of establishment charges, and under-utilisation of resources. Furthermore, the administration of such contracts by public bodies and their agents is more complex and costly than that of fewer, larger ones.

The use of targeted procurement enables contracts to be unbundled in a number of ways, i.e.

- by procuring works in the smallest practicable quantities (prime (minor and micro))
- by obligating prime contractors to engage SMEs in the performance of their contracts (prime (major)) in terms of resource specifications
- by requiring joint venture formation between large businesses and SMEs (structured joint venture)
- by providing third-party management support to enterprises that are not capable of operating as prime contractors (development contracts)

The unbundling strategies afford opportunities of participation to the full spectrum of SMEs, from those operating as labour-only contractors to those operating as prime contractors.

Engaging marginalised sectors of society in works contracts

The targeting of marginalised sectors of society (communities) in construction projects is invariably linked to employment-intensive works.

Frequently, it is associated with poverty alleviation and the purposeful flow of income to the poorest sectors of the community. The development of local enterprises is closely related to the community. The resources readily available are those in the community, i.e. local materials, local manpower, local machinery, and local money.

Projects involving communities may be classified as 'budget offer' or 'target market', depending upon the purpose for which funds are allocated, the nature of the asset to be constructed, and who initiates the project. 'Budget offer' projects are those in which a sum of money is set aside for a specific community to be provided with certain facilities and support within broad parameters and the flexibility exists for the endproduct to be determined, in both quality and quantity, by the process, without changing the budget. In budget offer (community-initiated) projects, community choices at every stage of delivery have an impact on the final product. Accordingly, training budgets can be project specific and funded through the project; less economically efficient delivery systems that meet the needs of the community can be considered and contracts can be set aside for members of the community to execute.

In the 'target market' category, the community is provided with facilities through normal channels of public sector expenditure, without the flexibility of the 'budget offer' approach, and its role is confined to the submission of inputs, the setting of targets, and the choice of delivery mechanisms in public sector procurement activities, within the constraints of value for money through Government agencies. Targeted procurement enables the 'target market' project category to be readily implemented.

The contract strategy adopted dictates, to a large degree, the extent to which communities can participate in construction activities. Participation can be secured by means of resource specifications and development objective/price mechanisms; goals may be set for the engagement of either local enterprises (local labour and local enterprises, including local suppliers and local manufacturers), or targeted labour. Participation can also be secured by means of joint venture formation with targeted enterprises within communities or by awarding labour-only and labour and material contracts and providing third-party management support to perform construction and materials management functions.

Appropriate specifications and technologies

The availability (or lack) of appropriate specifications and suitable technology choices can have a marked influence on the degree to which socio-economic objectives can be attained on works contracts by means of targeted procurement, particularly where the targeted labour option is used. The success or otherwise of some of the targeting strategies listed in Table 9 is very dependent upon technical choices being made available to tenderers. Appropriate specifications are required to optimise the engagement of smaller contractors and the increase in employment opportunities/unit of expenditure.

'Specifications' are documents prepared specifically to support procurement; they establish requirements in terms of method, quality or performance and, in some instances, in terms of more than one of these. Specifications should, in any event, define in a comprehensive, precise and verifiable manner the essential requirements for a deliverable item. Acceptance criteria to establish that specified requirements have been satisfied need to be an integral part of a specification.

Performance specifications on building projects involving housing, schools, hostels, etc., can permit tenderers to make technological choices that impact on both cost and socio-economic deliverables, such as the use of local resources, the increase in employment opportunities/unit of expenditure, or the provision of business opportunities to targeted enterprises. Performance specifications must state technical requirements, with criteria for verifying compliance but without necessarily stating methods for meeting the requirements. Technical performance criteria can be satisfied by designing structures in accordance with a set of rules, performing a rational design based on engineering principles, or obtaining Agrément certification¹⁵. Design-by-rule approaches can be formulated only for common forms of construction that are well understood, e.g. masonry walling and timber roof trusses. Rational designs, in turn, can be performed only on materials that have been well researched and tested and whose properties, characteristics and behaviour are well understood. Usually, a rational design approach is restricted to the preparation of designs in accordance with national Codes of Practice. However, the situation is complicated by the absence of suitable data on peripheral aspects of the design, such as resistance to rain penetration. Accordingly, the choice in technology is invariably between different conventional technologies; traditional forms of construction in developing countries are rarely considered. The absence of Codes of

TABLE 10 – Classification of materials¹⁶

Classification	Description
Soft, class 1	Material that can be excavated by means of a suitable shovel without the use of a pick or other hand-swung tool.
Soft, class 2	Material that can be readily excavated with the aid of a pick or other hand-swung tool.
Soft, class 3	Material that can be excavated with difficulty with the aid of a pick or other hand-swung tool.
Intermediate	Materials that are difficult to excavate by hand, even with the aid of a crowbar, and require the assistance of pneumatic tools for economic removal.
Rock	Material that cannot be economically fragmented and loosened for removal by hand implements and pneumatic tools, except by drilling and blasting or the use of rock-breaking equipment.

TABLE 11 – Classification of materials in terms of consistency and shear strength¹⁶

Materials classification	Consistency		Typical number of blows that a DCP requires to penetrate 100mm of material	
	Granular soil	Cohesive soil	Granular soil	Cohesive soil
Soft, class 1	Very loose/loose	Very soft/soft	≤2	≤1
Soft, class 2	Loose/medium dense/dense	Soft/stiff	2–6	1–5
Soft, class 3	Very dense	Stiff/very stiff	7–15	6–8
Intermediate	—	Very stiff	16–50	8–15
Rock	—	—	—	—

Practice to deal with some traditional forms of construction (e.g. round pole structures, thatching, and rubble masonry) results in them being avoided or approached circumspectly.

'Quality' may be regarded as conformance to stated requirements, rather than fitness for purpose. Small-scale entrepreneurs often have problems in achieving quality, depending on how it is measured and defined. Current practice is to define quality in terms of certain accepted criteria and to measure acceptance in terms of prescribed test methods and procedures. These are usually set out in national specifications or test methods which, to a large extent, have been formulated or drafted with the approval of industry and industry-related research and development organisations.

In general, these standards have been drafted to suit the needs of established industry and are framed around plant-based methods of manufacture and medium- to large-scale enterprises, which possess a reasonable degree of technical competence and testing resources. In addition, test methods and procedures for quality assurance are generally written for a scale of operation in which sufficient quantities for statistical purposes are manufactured and the cost of testing is relatively insignificant. Failure on the part of a small-scale manufacturer to comply with a requirement of these specifications (even a relatively minor lack of compliance) means that compliance with a national standard cannot be claimed. Thus, in effect, many of the current specifications present a barrier to entry to small-scale entrepreneurs and exclude their participation in a number of markets.

The National Home-Builders Registration Council in South Africa, in drafting its 1995 *Standards and Guidelines* (a document prepared to restrict mortgage lenders' risks of defects arising in housing to acceptable limits) departed from the conventional approach to the drafting of standards and kept references to South African national standards and Codes of Practice to an absolute minimum. Instead, the *Standards and Guidelines* listed salient and relevant requirements that needed to be satisfied: e.g. sands for mortar are required to comply either with the relevant requirements of SABS 1090, or with all of the following requirements:

- (1) They must not contain any organic material (i.e. material produced by animal or plant activities).
- (2) They must not contain any particles that are retained on a sieve of nominal size 5mm.

TABLE 12 – Criteria for classifying materials as soft class A excavation^{7,8}

Material type	Granular materials	Cohesive materials
Dynamic cone penetrometer – minimum number of blows required to penetrate 100mm	7–15	6–8
Consistency	Dense: high resistance to penetration by the point of a geological pick; several blows required for removal of material.	Stiff/very stiff Stiff can be indented by thumbnail; slight indentation produced by pushing a geological pick point into soil; cannot be moulded by fingers. Very stiff: indented thumbnail with difficulty; slight penetration of point produced by blow of geological pick.

(3) They must have a clay content such that a 'worm' 3mm in diameter can be rolled in the palm of the hand.

(4) When 2.5kg of common cement is mixed to 12.5kg of air-dry sand, the mixture may not require more than 3.0lit of water to be added to reach a consistency suitable for plastering or the laying of masonry.

(5) When mixed with common cement in accordance with the mix proportions, the mixture must have adequate workability.

Earthworks activities on construction projects provide excellent opportunities for increasing employment opportunities by substituting labour for capital-intensive equipment. However, a workable earthworks classification is required for payment purposes and to reduce a contractor's risk exposure should the latter elect to excavate materials by hand. Tables 10 and 11¹⁶ show such a classification, based on field recognition of the soil profile and *in situ* shear strength as measured by means of a dynamic cone penetrometer (DCP).

A suitable procedure to enable contractors to undertake portions of excavation work by hand methods is to permit tenderers to nominate the quantities of materials they would excavate using hand methods. The overall classification of material to be excavated can be in accordance with the relevant provisions of standard earthworks specifications. However, the quantity of soft excavation nominated to be undertaken by hand labour, using hand tools, can then be further broken down by the introduction of an additional class of material (i.e. soft excavation class A as set out in Table 12^{7,8}) and priced accordingly.

The challenges and constraints facing structural engineers

The challenge to structural engineers is, in the first instance, to understand the potential of construction projects for realising socio-economic deliverables and thereafter to use their skill, knowledge and creativity to attain them.

This is often easier said than done, particularly where unconventional or innovative technologies are required to be implemented on a large scale, particularly in view of:

- the lack of availability of technical information to enable informed design decisions to be made
- the lack of suitable on-site acceptance tests
- the reluctance of authorities to accept structures whose strength, stability, serviceability and durability cannot be quantified and assessed in terms of national or international Codes of Practice
- the reluctance of clients to pay for research and development

Clearly, structural engineers do not have the necessary resources to overcome the foregoing difficulties. Furthermore, structural engineers, who must assume responsibility for the safety of the structure, are naturally reluctant to place themselves at risk by deviating from accepted norms. In the absence of authoritative documentation and Codes of Practice, the contribution the structural engineer can make to the attainment of socio-economic deliverables is, accordingly, often limited.

The question that then begs asking is 'do structural engineers have a corporate responsibility to attain socio-economic objectives?'. If the answer is 'yes', what then are the vehicles and strategies for so doing?

The possible role of the Institution of Structural Engineers

Developing countries, where appropriate technologies are most needed, do not have the resources to undertake research into local forms of construction, nor do they possess the expertise to develop Codes of Practice and test methods that would enable innovative designs to be executed with confidence, as is the case for conventional materials such as concrete, masonry, steel, and timber.

Even where grant funding is provided to research particular technologies, there is no guarantee, for various reasons, that the research will be used in practice. Frequently, the deliverable in research projects is a set of guidelines that provides valuable insights into the subject-matter. These guidelines, however, rarely satisfy building authority requirements or public body needs, and seldom do they enable designers to execute designs with satisfactory levels of confidence. All too often, the research is structured to provide indicative, as opposed to quantitative, results, e.g. engineering properties are established on a non-statistical basis, and serviceability aspects, such as resistance to rain penetration, are ignored. Even when aspects relating to strength, stability, durability and serviceability are dealt with satisfactorily, such documents rarely enjoy widespread usage.

What is needed is for an institution with standing to lend credibility to documentation that is developed. This occurred recently when, in 1995, the Joint Structural Division (the South African Division of the Institution of Structural Engineers and the Structural Division of the South African Institution of Civil Engineers) published its Code of Practice for foundations and superstructures for single-storey residential buildings of masonry construction. The substructure aspects of this Code were based on a manual prepared by Watermeyer & Tromp for a local authority in 1990¹⁵, a document that was used on a few publicly funded developments under the local authority's jurisdiction. The Division's Code Committee made minor amendments to the material drawn from this manual and included it in its Code of Practice. It is now a requirement in South Africa that all housing that requires mortgage lending finance be designed in accordance with the provisions of this Code, the widespread use of which is attributed to the credibility afforded it by IStructE and SAICE.

There is considerable scope for IStructE to develop performance specifications for buildings, particularly housing. Such standards would enable non-standard forms of construction to be readily evaluated and deemed-to-satisfy design and construction rules to be formulated; they would also give direction to future research and set the deliverables for such research. (As a colleague has put it, 'you can't hit the bull if you don't have a target!'). There is also scope for the development of Codes of Practice and standardised designs for water storage and drainage structures and small bridges using materials that can be sourced in the rural areas of developing countries, e.g. rubble masonry.

There is an opportunity for IStructE to champion socio-economic responsibilities should it decide to:

- make its membership aware of the socio-economic deliverables that can be attained through various types of construction project
- develop and publish Codes of Practice and specifications that facilitate the linking of socio-economic objectives to targeted procurement
- encourage the development of on-site/point of manufacture test methods
- publicise case studies of the successes of structural engineers in attaining socio-economic objectives
- mobilise its membership to come forward in identifying technologies (new and old) that have the potential to realise socio-economic deliverables and to share information, based on their experiences
- inform and give direction to research initiatives embarked upon by others
- be the catalyst in bringing together research organisations, academic institutions, and practitioners, to share their needs and ideas
- engage with Governments to make them aware of what can be achieved.

Conclusion

The mission statement of the South African Joint Structural Division refers to 'The promotion of excellence in the practice of structural engineering for the benefit of the community'. Least-cost structures are not the only benefit that structural engineers have to offer the communities they serve. Structural engineers, by using their skills, knowledge, and creativity, can contribute towards the attainment of socio-economic objectives through construction projects.

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