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## What Causes Cost Overruns on Building Projects? - An Overview.

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# WHAT CAUSES COST OVERRUNS ON BUILDING PROJECTS? - AN OVERVIEW.

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Successful projects are those which are delivered safely to the required quality standards, on time, and within budget. The effective management of costs is a vital element in achieving these objectives. Clients rightly expect that the final cost of their projects should not exceed the approved budget, and indeed for some, cost certainty may be their main priority. Quantity surveyors (QS) are employed to manage the financial aspects of the construction process. Nevertheless, cost overruns are commonplace on construction projects.

Cost overruns during the construction phase may seriously over-extend the client financially, to the point where the project may not be finished to the expected standards, or may even have to be abandoned. The quantity surveyor must be focussed on preventing this from happening. Awareness of the source of overruns enables quantity surveyors to identify potential problem areas and to provide advice on how to avoid them and/or how best to mitigate their negative effects. This study investigates the main causes of cost overruns during the *construction phase*<sup>1</sup> of traditionally procured medium-sized building construction projects. The study also provides a background for a companion paper entitled *Cost Control During the Construction Phase of the Building Project – the Consultant Quantity Surveyor’s Perspective* (Cunningham, 2017), which is published on-line at the Dublin Institute of Technology ‘Arrow’ repository.

## Cost overruns

‘Construction and engineering projects are risky ventures: 40% are late; 50% over budget; 30% fail to meet expectations of users’ [Rethinking Construction UK DTI, 1998] quoted by the Department of Finance, (2008).

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<sup>1</sup> Readers may wish to refer to a study ‘*Cost Control during the Pre-Contract Stage of a Building Project – An Introduction*’ (Cunningham, 2015) which examines how quantity surveyors manage costs during the design phase of construction projects. Available at: <http://arrow.dit.ie/beschreoth/49/>

Construction projects are dynamic and risky ventures where outcomes are often uncertain. The industry is characterised by the construction of one-off bespoke buildings on sites whose conditions and constraints are highly variable. Each project involves unique design and construction challenges which are typically undertaken by temporary organisations assembled for the particular project; - lessons learned are difficult to capture in these environments. Projects often take a long time to complete and there are often competing pressures between time and budget. In addition, the construction market is highly cyclical with consequent pressures on resources (Department of Finance, 2008).

Risks are inevitable and cannot be completely eliminated (Hughes, Champion and Murdoch, 2015). No matter how well the project has been planned, events *will* occur that complicate or change the basis on which the project was originally planned and priced. Many of these events will give rise to additional costs in completing the works. Ultimately, somebody pays for this. The employer usually pays for the additional costs arising from particular classes of architect's / employers representative's instructions. Employers are also be liable for their own, and/or their consultants' defaults which delay and/or disrupt the contractor's progress. Additional costs resulting from various 'neutral' events beyond the control of either party, for example extreme weather, lie where they fall, and frequently both parties may suffer loss as a result. Contractors must absorb additional costs where they are at fault, or where a risk eventuates which they control or have agreed to undertake. When risk and uncertain events occur cost overruns and delays are likely.

Cost overruns reduce the effectiveness of investments and require additional finance to be raised. On public works contracts cost overruns divert funds from other projects, creating negative knock-on effects in the wider economy. In the private sector the additional costs must be funded from reserves or borrowed. In contracting organisations, poor cost performance reduces or eliminates profit margins. In extreme cases this may lead to project or company failure (Hongtao, 2014). Cost overruns, therefore *are* a major problem for construction clients, project managers and construction companies alike. They cause disputes, frustrate project objectives, and strain ongoing business relations. Preventing cost overruns, therefore, is a key objective during the execution of construction projects.

## Causes of Cost Overruns.

Surprise, Surprise!

Cost overruns occur on many construction projects, although of course, their magnitude varies considerably from project to project. It is important, therefore, to investigate the causes of cost overruns in order to develop an understanding of how and why they arise, so that corrective action can be taken, at source, to avoid or limit their negative impacts. For the purposes of this study cost overruns may be considered to be the extra cost of the difference between the final account and the contract sum.

The link between risk and cost overruns has already been indicated above, and it has been observed that construction *is* indeed a risky business. Hughes *et al.* (2015) refer to Max Abrahamson's and Nael Bunni's summaries of risks which may affect construction work. These are reproduced here in full (p. 94/95):

- **Management direction and supervision:** greed; incompetence; inefficiency; partiality; unreasonableness; poor communication; mistakes in documents; defective designs; inadequate briefing, consultation or identification of stakeholders; compliance with statutory requirements; unclear requirements; inappropriate choice of consultants or contractors; changes in requirements.
- **Physical works** - ground conditions; artificial obstructions; weather; defective materials or workmanship; tests and samples; site preparation; inadequacy of staff, labour, plant, materials, time or finance.
- **Delay and disputes** - possession of site; late supply of information; inefficient execution of work; delay outside both parties' control; layout disputes.
- **Damage and injury to persons and property** - negligence or breach of warranty; uninsurable matters; accidents; uninsurable risks; consequential losses; exclusions, gaps and time limits in insurance cover.
- **External factors** – environmental regulation; government policy on taxes, labour, safety or other laws; planning approvals; financial constraints; energy or pay restraints; cost of war or civil commotion; malicious damage; intimidation; industrial disputes.
- **Payment** - delay in settling claims and certifying; delay in payment; legal limits on recovery of interest; insolvency; funding constraints; shortcomings in the measure and value process; exchange rates; inflation.
- **Law and arbitration** - delay in resolving disputes; injustice; uncertainty due to poor records or ambiguous contract; cost of obtaining decision; enforcing decisions; changes in statutes; new interpretations of common law.'

This is indeed a sobering list of potential problems. Hughes *et al.* (2015) note the

challenge of calculating an appropriate premium to cover these issues at tender stage, and question ‘*the extent to which they can be predicted at all*’. They advise practitioners to develop a risk management strategy to identify the likely range of outcomes associated with the various risks in order to develop appropriate responses to them.

Chan and Kumaraswamy (1997) identified 83 factors which can delay a construction project. They grouped these factors into eight major categories and concluded that “*the five principle and common causes of delays included poor site management and supervision, unforeseen ground conditions, low speed of decision making involving all project teams, client-initiated variations and necessary variations of works.*’

In a previous study *Factors Affecting the Cost of Building Work – an Overview*<sup>2</sup> (Cunningham, 2013) the author outlined the main reasons why costs vary among different classes of buildings. Many of the factors examined in that study also relate to cost overruns during the construction phase. It is considered opportune, therefore, to revisit the study in order to examine these links.

### ***The Influence of the Client***

A common problem encountered on building contracts concerns clients with little or no experience of the construction process. Many construction clients are one-off or ‘occasional’ developers, and so, need considerable assistance from competent professionals to enable them to formulate a comprehensive brief, and to become aware of their statutory and contractual duties. Hongtao (2014) notes that problems often arise where clients do not have a clear vision of what they need and want. He indicates that this may result in design teams making assumptions which turn out to be less than ideal from the client’s perspective and which consequently prompt ‘inevitable’ changes. He adds that inexperienced clients may also be slow to make urgent decisions and, further, that clients may not realise the full implications of their expectations and/or decisions. Hongtao interviewed a quantity surveyor who recalled his experience of a challenging €12 million renovation project where over 200 variation orders were issued, the client was slow in making decisions, and a cost overrun of 23% was recorded. “*The client was very eager to start on site as quickly as possible and the intention was to issue the*

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<sup>2</sup>Available at <http://arrow.dit.ie/beschreoth/27/>

*information as and when it required on site. The speed of the initial planning and lack of detail led to many matters which had to be resolved on site and led directly to the eventual poor cost performance outcome.”*

The client’s attitude towards cost certainty is an important influence on whether a project will be carried out within budget. Certain clients may have fixed budgets which may not be exceeded in any circumstances and will expect the quantity surveyor to maintain rigorous cost control during the project. In this regard, cost certainty is a key objective in the delivery of public sector construction projects.

Other clients, however, may place a greater emphasis on completing the project within a quicker timescale. One of the chief criticisms of the ‘traditional’ procurement arrangement is the length of time taken to appoint a contractor relative to other ‘fast-track’ approaches. Time is money and private sector clients must fund the design and construction phases before generating returns on their investments. It is possible to accelerate the overall programme by overlapping the design and construction process. This can be achieved by tendering the work on incomplete information using prime cost sums, provisional sums and approximate quantities as budgets to cover the expected building costs. The outturn costs of PC and provisional sums, however, are subject to negotiation and agreement with the contractor at the final account stage, and their valuation is typically based on the actual costs of carrying out the work, rather than the sums contained in the contract. There is often little incentive for the contractor to economise in carrying out these works. Approximate quantities, likewise, are subject to remeasurement on completion. In both instances there is the possibility that the budgeted amounts or provisions made may be inadequate and cost overruns will result. As Hongtao’s example above, illustrates, the more ‘outline’ the design information, the greater the margin for error. It is partially for this reason that the State prohibited the use of prime cost sums, provisional sums and provisional quantities on public sector works contracts.

Clients may also impose unrealistic schedules as part of their requirements. Chan and Kumaraswamy (1997) identified unrealistic contract durations as the third most significant factor ranked by contractors in causing delays in building projects in Hong Kong. Speedy construction, involving overtime, weekend work and shift work is

expensive. Compressed project time-scales often demand intensive management and precise coordination of work activities on site. Where complications are experienced it may become necessary to accelerate the works, with inevitable consequent cost implications.

Clients also, quite naturally, want the best quality they can afford, and it is to be expected that their aspirations will, occasionally at least, exceed the provisions included in the budget. As in other areas of life, lack of restraint often causes difficulties.

### ***The Influence of the Architect.***

The architect as lead designer / contract administrator, ultimately, is the person who has to explain the reasons for the cost overruns to the client. He/she will not relish presenting bad news on the cost front. As the ‘commanding officer’ of the contract he/she exerts considerable power and influence as to whether and/or to what extent cost overruns occur. The choice of architect will typically reflect the client’s priorities, particularly those related to cost and quality. Clients who plan to develop high quality or landmark developments often employ high profile design practices. High expectations are usually linked to high prices, and such clients will expect to pay a premium for this service. Architects, quite naturally, may be reluctant to drop quality standards and compromise their ‘brand’ on the grounds of cost, and it may be difficult for the quantity surveyor to prevent costs from rising in these circumstances.

Architects and designers instinctively, and by their training, seek to develop the best possible solutions for their clients. The design process is iterative in nature and remains ongoing during the construction phase. Regardless of whether a ‘comprehensive’ design has been developed, there is a continuing desire to improve the end product. During the construction phase the ‘finishing touches’ are applied to the project and clients are often requested to consider design improvements or to revisit earlier decisions taken on cost grounds. In this regard, retrofitting is an expensive option in comparison to incorporating improvements as part of the building contract. Individual architects may be particularly ‘persuasive’ on this point. While such modifications would be regarded as ‘approvals’, they nevertheless deplete the contingency retained by the client to deal with other surprises. There also remains the danger that the designers, perhaps in an attempt to ‘future-proof’ the building, may introduce cutting

edge solutions and technology where these are not really needed or where more expensive options are preferred to the original, more functional proposals - 'gilding the lily' comes to mind. The risk of cost escalation from these sources is clear therefore.

Inadequate performance of the architect, and indeed, the other design team members in carrying out their duties is a frequent source of delays and disruption of the contractor's progress. Chan and Kumaraswamy (1997) identified (i) 'delays in design information;' (ii) 'long waiting time for approval of drawings,' (v) 'mistakes and discrepancies in design documents,' and (vi) 'long waiting time for approval of test samples' among the top six responses from contractors ranking significant factors causing delays in building projects. Delays occurring due to these reasons have direct cost implications.

### ***The Nature of the Project***

This study assumes that a traditional procurement arrangement has been selected and the design and specification of the project have been substantially completed.

### ***The Nature of the Site***

'A mosaic of erratic geological conditions owing its nature to the caprice of ancient ice' (O'Connor quoted in Keane, 2001).

Although the site is examined by the architect and structural engineer in formulating the design, and which, on substantial projects is typically quantified by the QS, and is also visited by the contractors in preparing their tenders, surprises in the ground are by no means uncommon. Knowles (1992) comments that '*Too many projects have designs based upon inadequate soil information. All too often Employers are not prepared to invest the necessary money at the outset. When work commences on site unexpected ground conditions lead to variations, delays and claims.*' In the UK, the Institution of Civil Engineers (1991) reported that '*the largest element of technical and financial risk lies normally in the ground.*' The Institution referred to UK NEDO (National Economic Development Office) research which found that:

- 37% of a representative group of 56 industrial projects suffered delays due to ground problems. Without exception on second hand sites unforeseen ground conditions were met during construction.



- 50 of a representative group of 60 commercial projects suffered delays due to unforeseen ground conditions.
- Geo-technical problems on eight roads and six bridge projects resulted in extra work costing £18 million (1981 prices).
- On ten large highway construction projects, the final cost was on average 35% greater than the tendered sum. Half of this increase was due to inadequate planning of ground investigation or poor interpretation of the results.

The Institution commented that most construction activities involving the ground are sufficiently close to the critical path for any delay to those activities to affect the whole project.

Ashton and Gidado (2001) indicate that a large proportion of design-and-build contractors have reported difficulties when carrying out substructure works as a result of uncertain ground conditions. They claim the difficulties were often due to the actual site conditions differing from those portrayed by the site investigation reports. They refer to Alhalaby and Whyte's research that concluded *"90% of risk to projects originate from unforeseen ground conditions which could often have been avoided by adequate and full site investigation."*

Unforeseen ground conditions may be sufficiently adverse to necessitate a redesign of the foundations. Redevelopment projects, so-called 'brownfield sites', present particular risks in this regard and may generate significant additional site clearance and remediation costs where unexpected difficulties are encountered. Challenging sites such as those with difficult or restricted access, or heavily sloped sites may present difficult working conditions which reduce the planned productivity of operatives and plant. The cost of dealing with unforeseen poor loadbearing ground conditions, ground water, rock, archaeological finds and encountering uncharted buried services may also be substantial.

#### *The Effect of the Design: Scale, Complexity and Innovation*

In traditional procurement arrangements the contractor typically tenders a lump sum price to complete the works. All other things being equal, there should be no difference between the contract sum and the final account. However many matters can derail the original plans and cause additional costs as a result.

While the design itself may be finalised, the construction activities must be carefully managed in order to meet the contractor's cost targets. The larger and more complex the project, the greater the challenge becomes to control overrunning costs (Rowland, 1981). It is not difficult to find high profile examples of spectacular cost overruns on-line and in the popular and technical press. Rowland comments that '*the larger the project gets, the greater the margin for error*' and notes that managerial spans of control often become over extended in these situations. He also notes that coordinating different design phases becomes more complex and that information feedback becomes distorted as communication channels become '*longer and longer*'.

Larger projects also tend to be more complex and/or more innovative. Complexity implies that the construction work is not simple, and such work often involves the cooperation and coordination of a number of individuals, trades and/or specialists. Rowland (1981) found that as job complexity increases, so too, do the number of change orders. He indicates, however, that the complexity of a particular job must be '*markedly distinguishable before an increase in the number of change orders can be expected.*' Rowland plotted various categories of construction projects against the number of change orders per job. He found that commercial construction had the lowest average number of change orders. Industrial construction and specialized construction experienced the next highest incidence of change orders. Heavy construction was found to experience the greatest number of change orders per job. He comments that commercial projects could be described as '*unspecialised, light construction*'; specialised works as '*unique*'; industrialised work as involving '*specialised equipment*', and, heavy engineering as involving '*unforeseen conditions*'.

Odeyinka, Kelly and Perera (2009) found that the budgetary reliability of bills of quantities in procuring buildings in Northern Ireland deteriorated as the projects became more uncertain and complex. They reported a -3% to +4% deviation on five housing projects; a -4% to +17% deviation on five educational projects; a -20% to +20% deviation on five commercial projects and, a -11% to +37% deviation on five refurbishment projects. They suggest that the more complex the project is, the less reliable it is to use the BQ to achieve cost certainty.

Hughes *et al.* (2015) comment that traditional general contracting using bills of quantities is not suitable where PC sums and provisional sums (see below) constitute the majority of the buildings cost. PC sums are used to appoint employer-selected specialist sub-contractors and/or suppliers. Provisional sums afford budgets for works which have not been fully defined or designed and are also used to provide for various contingencies. PC and provisional sums lend themselves to valuation by cost reimbursement rather than by 'pro rata' payment approaches. They add that if PC and provisional sums make up a large proportion of the works that this reduces the main contractor's role to a co-ordinator and accountant rather than a builder and that traditional contracts do not reflect this role.

### *Specialist Work*

Specialist works have traditionally been carried out by nominated subcontractors selected by the architect/employer but who are employed by the main contractor. This arrangement is provided for in the RIAI Form of Contract. The nomination process enables architects to appoint particular subcontractors to carry out specialist work packages, or specialist suppliers to supply materials to the main contractor. These subcontractors are typically chosen because of their track records for delivering high quality work, and, in many instances for completing specialised areas of design. A similar arrangement is provided for in the Public Works Contracts where a 'reserved' contractor is selected by means of a separate tender competition independent from the main contract, but whose appointment is subsequently novated to the contractor as a *domestic* subcontractor. Nominated and reserved contractors command a premium.

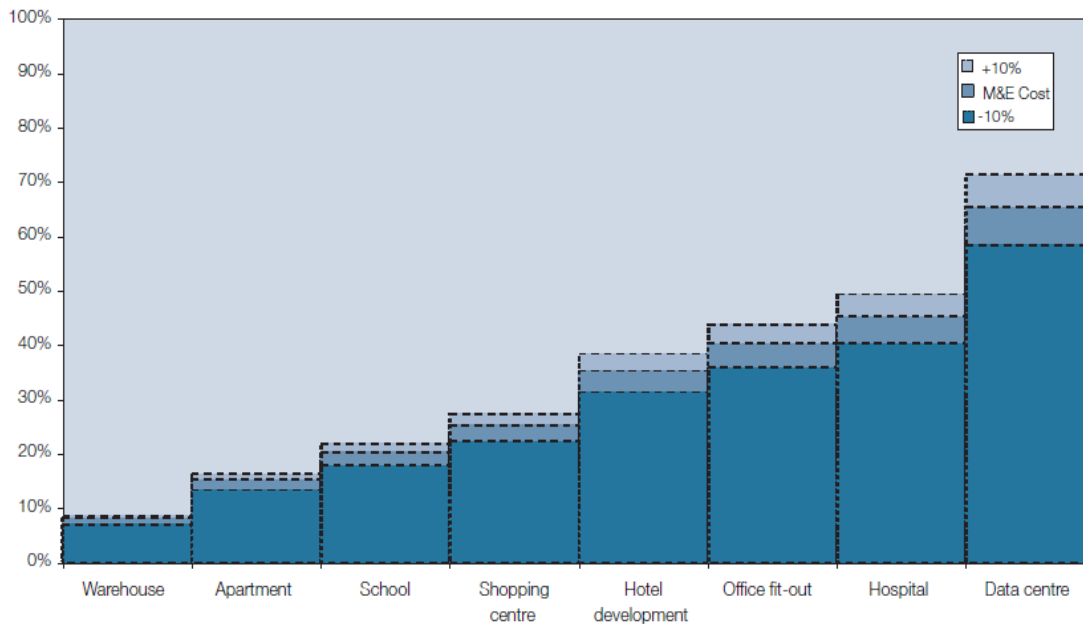
The employer's requirements regarding specialist areas of design are often expressed as performance specifications, where the specialist finalises the 'core' design proposals developed by the design consultants. The detailed design, the interface between the specialist work and the general fabric of the building, and the connections to the other (specialist) systems, however, may not be fully clarified in the tender documentation. These often need further exploration on site and 'fine tuning' may be required to resolve clashes and to successfully integrate the various specialist technologies and systems. This process takes time (money) to complete.

Nomination is typically arranged on the basis of *prime cost sums* (PC Sums) included in the contract documents. These sums are *budgets* and are usually based on best estimates provided by the QS or the consultant associated with the specialist works. Prime cost accounts operate a cost reimbursement payment arrangement where the main contractor is paid the nominated subcontractor's or supplier's price (approved by the architect) to which the main contractor may add sums to cover profit and attendance. These accounts are adjusted in the final account. Main contractors, however, have little incentive to control costs under this arrangement as they do not gain any benefit from cost reductions or savings made within the nominated subcontracted / supply accounts. Nomination shifts the pricing risk from the contractor to the employer. PC Sums, as a result, can be difficult to control and they have a reputation for causing cost overruns.

The alternative approach to nomination involves measuring the specialist work, this presents different challenges. The measurement of specialised design requires a detailed knowledge of the particular technology and an understanding of how this is to be incorporated into the overall scheme design. This information is not available until the specialists complete their design proposals. The QS, consequently, is not well positioned to measure such work accurately in advance and also may have limited experience of the proposed particulars, technology and/or systems. Attempts to specify and quantify such work, therefore, may be problematic.

#### *Mechanical and Electrical Installations.*

The provision of mechanical and electrical services (M&E) is becoming an ever more important component of a building's overall cost. The extent of the M&E content depends, of course, on the function of the building. Figure 1 indicates that its extent may range from approximately 10% for warehouse type projects to approximately 60% in the case of data centres. Latham (1994) comments that the more complex the building, the higher is the likely value of the M&E input, and occasionally, the value of the M&E content may exceed the builder's own work. It is clear that the control of this aspect of the project's budget demands particular attention.



**Fig 1 M&E as a percentage of the total construction cost. (McCaffrey, 2010)**

On private sector projects M&E works are frequently included in the tender documents as a PC sum. At the outline cost plan stage, the budgets for the M&E content may be based solely on cost analyses of previous projects and expressed as a percentage of the overall building budget. So, for example, the mechanical and electrical budget for a school might be set at 20% of the overall building cost. However, this ‘rule of thumb’ historic budgeting approach has no real basis in the form and function of the project’s design. The budget simply represents a limit the consultant ‘has to play with’. The adequacy of such budgets should be ‘firmed up’ as the design develops. At tender stage the PC sum for the services may still be based on a ‘typical’ cost per square metre of the floor area. Again, this sum may not adequately reflect the geometry and particulars of the actual building.

The actual cost of the specialist component is eventually established when the works packages are tendered. Ideally this should happen before the main contract is let, but frequently the specialist works are tendered during the construction phase; particularly when the client seeks fast track solutions. In general, the consulting engineer provides the ‘overall’ design on schematic (general arrangement) drawings and also provides performance and particular specifications. The M&E subcontractor finalises the detail design using these documents (Latham 1994). Latham comments that the relationship between the consulting engineer and the M&E subcontractor can be ‘*problematic*’

referring to a *'fuzzy edge disease'* in describing the design responsibility between the consultant and M&E subcontractor. The resulting pricing process often involves the M&E subcontractor in having to interpret the consultant's intentions regarding ambiguous or missing elements in the brief. Problems may arise when a budget has been viewed as a target rather than a limit. The resulting tendered prices may come as a shock!

James Nisbet, a former President of the Quantity Surveyors' Division of the Royal Institution of Chartered Surveyors contributed the following passage to the Latham Report regarding the design complexity and the potential for lack of co-ordination arising from this procurement arrangement.

Architects are expected to produce working drawings and the builder is expected to carry out works in accordance with such drawings. The structural engineer relies upon the manufacturers to design the connections for a steel frame. The services engineer expects a subcontractor, appointed after the builder, to prepare all installation (i.e. working) drawings. Design co-ordination before construction starts is therefore impossible and ad hoc alterations on site are inevitable. Further, the tender and contract procedures adopted by architects and service engineers are at variance one with the other and this leads to difficulties and animosity in the management of cost and the administration of the contract conditions. Architects' designs are usually the subject of Bills of Quantities but services engineers resolutely require tenders to be based on drawings and specifications. The common range of conditions of contract place responsibility for the cost of a project solely upon one person, usually an architect or engineer. The procedures adopted by the services engineer effectively prevent the architect or engineer from exercising control over the cost of the services element of a project. Urgent attention should therefore be given to the elimination of this muddle (Latham, 1994 p. 24).

Mitchell (2016) found that M&E works packages in Ireland are normally procured in the above manner; - i.e. tendered on schematic drawings and a performance specification basis, with the specialists developing, quantifying and pricing their own detailed proposals. He notes that this *'seems to be long established practice'* and is one that is widely used abroad.

The M&E components of a building project are unique in that they consume valuable resources: water, gas and electricity, - it costs money to operate them. There is a more obvious trade-off here between capital and running costs than in other elements of the building. The previous discussion regarding designers seeking optimum design

solutions becomes particularly relevant in this context. Value for money often comes at a price, and schemes selected on the basis of low capital cost may not offer best value for money in the long run. In these instances, the consultant engineer may consider the extra cost to be worthwhile in selecting or approving particular systems.

In the past, the financial control of M&E budgets was carried out by consultant engineers rather than by quantity surveyors. David Cunningham (2011) quotes the Sullivan's critique in the *RICS Construction Journal* (April, 2010) of this arrangement.

It wasn't so long ago that M&E costs were provided by the M&E consultant and the QS simply included the costs in the cost plan, or inserted a prime cost sum in the tender documentation. We all tended to rely too much on the consulting M&E engineers who were not trained to deal with costs and probably saw these as a sideshow compared to the real job of getting something designed and built.

The recent review of the performance of the Public Works Contract prompted the reinstatement of bills of quantities measured in accordance with ARM4 as the primary pricing document and mandated that mechanical and electrical works be measured in accordance with its rules. This is a new departure. Mitchell (2016) notes that Irish M&E contractors have had limited exposure to measured bills of quantities particularly those measured in accordance with a standard method of measurement. He adds that incomplete designs and a lack of technical knowledge among quantity surveyors have been barriers to the measurement of mechanical and electrical services in bills of quantities: *'fully measured bills of quantities have rarely been produced in relation to mechanical and electrical services in Ireland.'* He found, nevertheless, that M&E contractors acknowledged that the QS is best placed to control costs *'but have a long road ahead in relation to upskilling on the technology side.'*

Despite the above views that quantity surveyors may be better at controlling costs than services engineers, the problem nevertheless remains that many quantity surveyors currently have insufficient experience, expertise and lack the necessary comprehensive cost databases to successfully control costs this specialist aspect of the project. This difficulty may be compounded by the reluctance of the sector to relinquish its traditional independence and work practices in response to what might be viewed as 'outside interference'. Quantity surveys may find a less than whole hearted welcome in entering this field. There are obvious (cost) risks in venturing into unknown territory.

### ***The Procurement Arrangements***

Procurement refers to ‘*the process of obtaining goods and services from another for some consideration*’ (Hackett, Statham and Robinson, 2007). The study *Factors Affecting the Cost of Building Work – An Overview* outlined the characteristics of traditional, design and build, and management procurement approaches; commented upon the implications of various standard payment arrangements; reviewed common contractor selection and tendering options, and discussed the consequences of unclear contract documentation. All of these matters influence the degree to which cost certainty can be achieved.

In relation to cost overruns on traditionally procured projects, the primary financial risks borne by the client relate to the design and the measured quantities. The consequences of defective design, while not the particular focus of this study, can be disastrous and must be covered by professional indemnity insurance and/or bonded collateral warranties where the design is carried out by specialist subcontractors.

The quantities risk, on the other hand, is of fundamental concern to quantity surveyors. Bills of quantities form part of the contract on most substantial Irish building projects. This arrangement means that the accuracy of the quantities is guaranteed by the client. Incorrect quantities are corrected, missing work items are added. Quantities may be under measured in bills of quantities due to factors such as human error, lack of technical knowledge of specialist systems, and/or incorrect assumptions regarding (missing) details. Mistaken quantities are regarded as a discrepancy within the contract documents and they are corrected on foot of an Architect’s/Employer’s Representative’s Instruction, - the dreaded variation/change order.

Under the traditional procurement arrangement, the pricing risk is retained by the contractor who tenders a lump sum price for the project. The contractor’s rates are not adjusted in the event that the works cost more than expected. Traditional procurement arrangements are also characterised by the use of competitive tendering whereby the contractor submitting the lowest bid is generally awarded the contract. This process, however, suppresses contractors’ profit margins in seeking to win work. Premiums for risks borne by the contractor are often (heavily) discounted, particularly when competition is intense or work is scarce. If things go wrong, or if the project is



mismanaged, or if the tender is below cost, the contractor may experience cash flow difficulties, or worse. In these situations the contractor may have little option other than to become ‘claims conscious.’ This is a well-known phenomenon amongst quantity surveyors. What may initially appear to be a ‘bargain’ rarely comes with no-strings-attached. A senior quantity surveyor interviewed by McCaul (2011) made the following comments in this regard:

Nobody in business sets out to make a loss, they are in business to make money. Imagine that a company who takes some a job below costs has seen something in the contract documents that they can take advantage of. A flaw that the client did not expect was there. I have seen that situation. You think you have bought the project at a 25% discount; the reality is that the builder has a plan to recover that. In theory there is a flaw in the contract documents, and that the builder is entitled to get that 25% back, but that’s all very well in theory, but in reality it leads to fractious relationships. It leads to the builder on the ground trying to make it work for less than the €10m. It leads to him trying to procure things in a peculiar way that maybe, is not in the long term interests of the building, and the owner of the building, but in the short term interests of the builder. You would just have to worry about what type of building you would get out of it. ... I have yet to see a set of contract documents that are bullet proof.

A further difficulty arises where a contractor, appointed following an open tendering competition, does not possess the technical or managerial capability to carry out the project to the required standards. Incompetent contractors invariably cause trouble and poor workmanship, delays, and exaggerated or disputed payment claims are common issues when dealing with such contractors. The costs of rectifying defective work and/or the additional expense arising due to delayed delivery are passed on to the contractor, who, no doubt, will attempt to recover them. Replacing incompetent or insolvent contractors invariably costs significantly more than the original contract sum. The extra cost involved in this action may not be fully covered by the standard bonding arrangements currently in place.

### ***The Degree of Design Completion***

If it’s not on the drawings – it’s not in the price.

It is rare for designs to be completed to the extent that a project could be built precisely in accordance with the original drawings and specifications. If the contract documents are not precise then the price cannot be precise. Many, if not most, financial problems

encountered on building projects originate in incomplete or unclear contract documents.

The compilation and production of accurate tender documentation is one of the key tasks performed by the QS during the pre-contract stage of the project. One of the main benefits of employing a QS to measure bills of quantities is that when he/she spots gaps in the design information, he/she can question the design team as to what is required, and press the design team to finalise and issue the outstanding information. This interrogation of the design resolves instances of what otherwise would resurface as contractors' requests for information and requirements for variations during the construction stage.

However, there is only so much that the QS can do to provide for areas which have yet to be designed. As noted above, the client may prioritise early completion over cost certainty and be prepared to commence work on the basis of a 'planning stage' scheme design. In such circumstances the QS may include *provisional sums* in the bills of quantities to provide for "work or costs which cannot be entirely foreseen, defined or detailed at the time the tendering documents are issued" (ARM 4, 2009). This mechanism is another form of a 'cost reimbursement' arrangement whereby the contractor is paid what it costs to complete the particular work. Again, the employer bears the pricing risk and, as is the case with prime cost sums discussed above, there is little incentive for contractors to complete such works efficiently.

An alternative approach is to include *provisional quantities*, also known as '*provisionally measured work*', where the type of work is known but its extent is not. This mechanism is often used to cover matters such as groundworks, builder's work in connection with services, and remedial works, whose extent could not be accurately established in advance of opening up or site inspection. Under this arrangement the employer bears the quantities risk.

#### *The quality of the contract documentation*

A related problem arises in the case of poor and/or inaccurate tender documentation. Discrepancies and inconsistencies may occur among: the general arrangements; the detailed drawings; the various consultants' drawings; the specifications; schedules, and bills of quantities. Such discrepancies may result in the contractor carrying out the work

in the wrong place or in the wrong manner. Correcting such mistakes must be paid for if the contractor is not at fault. As noted above, mistaken quantities must be corrected.

More problematic however is where the design and specification have been given inadequate consideration during the design phase. This may occur where the client's brief has not been fully developed or the design process has been poorly managed. Correcting poor or impractical designs and specifications may involve significant reworking the original design. These revisions may delay the start of the project. Similarly, the introduction of variations during the course of the construction can certainly delay its completion.

Ambiguous contract terms and inconsistencies between the various contract documents are also a common source of disputes.

#### *Variations*

Put simply, varied work costs more.

Variations / change orders are an indication that something has not gone to plan and where these are numerous a conclusion may be drawn that project has been poorly planned (Rowland, 1981). Variations are almost inevitable on all but the simplest of building contracts. Each building project is unique and has its own particular design and construction challenges. No matter how well the project has been planned, architects will almost certainly need to issue further drawings, details and instructions for some reason or another. These instructions allow designers to fine tune the scheme to better achieve the client's requirements. However this flexibility comes at a price, the cost of the project and/or the time taken to complete it are usually affected in some way. The extent of variations can range from minor alterations to major scope changes.

Hughes *et al.* (2015) explain that there are three ways in which variations might arise: (i) clients may change their minds about what they asked for, (ii) designers may not have finished all of the design and specification work, and (iii) changes in legislation and other external factors may force changes upon the project team. They explain that client-instructed variations are '*the prerogative of the client.*' On occasion clients may need to leave certain design or specification issues until after the works have commenced. They note that the design is rarely completed at the time of the tender and

changes may be necessary ‘*simply to make the building work.*’ Incomplete design and shortcomings in the briefing process are a common source of variations. Potts (2008) identifies inadequate briefing, late and inconsistent client instructions, incomplete design, poor planning, lack of coordination of specialist designs and late clarification of complex details as problem areas. The rectification of design errors (March, 2009), inadequate time allowance for design, poorly prepared tender documentation, and insufficient attention to detail (Laryea, 2011) are also common sources of variations. This general lack of professional discipline is directly connected to the need to issue variation orders, and is avoidable.

### ***Risk from External Factors***

Murphy’s Law
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The third source of variations, external factors, is typically beyond the control of the parties. Variations may be necessary to deal with unforeseen events and contingencies, especially on groundworks and refurbishment/restoration projects. For example, foundations may need to be underpinned; problems are often revealed when existing buildings are opened up; specified materials may not be available, or storm damage may necessitate rebuilding work. External events such as changes in legislation and government policy may also prompt variations. Disputes can be costly to resolve, particularly where awards are appealed.

Risks rise from many sources and these may delay the project, (Hughes *et al.* 2015, Chan and Kumaraswamy 1997 above). The various Irish standard forms of contract specify a list of events for which an extension of time, or use of a ‘programme contingency’, can be awarded. While extensions of time generally do not affect the cost of carrying out the work itself, they do mean that the contractor must maintain the site for a longer period than was originally planned, thereby reducing the profit margin. In addition, clients will not be able to occupy the works on time, incurring additional financing and/or alternative accommodation costs as a result. The loss lies where it falls.

In this regard Clause 30 of the RIAI contract permits extensions of time for delays caused by ten events: (i) force majeure; (ii) unavoidable inability to secure labour or

materials; (iii) exceptionally inclement weather; (iv) reinstatement of damaged work covered by insurance; (v) strike or civil commotion; (vi) architect's instructions; (vii) late instructions; (viii) delayed granting of possession of the site; (ix) delays caused by the employer's direct employees, and (x) other acts of employer default.

Similarly The Public Works Contracts permit the use of the *Programme Contingency* for up to twenty *Delay Events*: these are: (i) change orders; (ii) unnecessary opening up of works; (iii) employer instructs a work suspension; (iv) the contractor justifiably suspends work; (v) incorrect setting out information; (vi) early partial possession; (vii) late instruction; (viii) failure to provide the contractor with access to works; (ix) failure to provide a works item; (x) employers personnel delay the works; (xi) rectification of work not damaged by contractor; (xii) rectification of damaged work covered by insurance (xiii) a weather event (xiv) strike; (xv) court order suspending work; (xvi) employer default; (xviii) unforeseeable archaeology; (xix) unforeseeable ground conditions (xx) unforeseeable utilities encountered, and (xxi) unforeseeable delays caused by utility providers. Note that item (xvii) relates to incorrect quantities which is *not* a delay event.

The risk of delay relating to the unforeseeable ground conditions contained in items (xviii) to (xxi) (encountering unforeseeable archaeology, ground conditions, uncharted buried utilities and delays by utility providers) may be transferred to the contractor if the client is of the opinion that the contract documentation is sufficiently detailed enough to allow the contractor to adequately evaluate the particular risk(s).

Many of the above delays, may be due to failings of the employer or the contract administrator. These may also entitle the contractor to seek reimbursement of loss and expense incurred by the delay and disruption of the work (see below).

### ***Market Factors***

The performance of construction industry is widely viewed as a useful indicator of the performance of the wider economy. The industry is highly cyclical and experiences booms and busts on a regular basis. The recovery and growth phases of the economic cycle are often characterised by strong demand for construction related services and products. Supply shortages often emerge during these stages, fuelling demand for

higher wages which ultimately are passed on to the end purchaser. Construction *tender price inflation* rates run significantly higher than general inflation during these periods and can at times be multiples of the general inflation rate. Inflation is a particular concern on projects with long construction programme durations where an inflation buy-out has not been arranged at contract award stage.

The downside of the economic cycle, on the other hand, exposes construction clients to the risks associated with under-priced work and abnormally low tenders, the consequences of which have been discussed above. In this regard Rowland (1981) comments that cost overruns are common on projects where the contractor's tendered price is below the 'engineers' estimate.

### ***Poor Project Management***

The success of any construction project depends on how well the various participants carry out their duties and responsibilities. As noted above, construction is a highly complex and fragmented process requiring the input of many individuals and firms in the task of completing the project. Effective and efficient team working is vital. This is a challenging task as many of the participants have competing objectives. Each participant must know their own role and their relationships with the other team members in order to effectively contribute their expertise to achieve a successful outcome. The attitude, competence and experience of the client, the architect/employer's representative and the contractor are key factors affecting the success of the project.

The standard forms of contract used in Ireland permit the contractor to be granted an extension of time if one or more of the listed events on page 20, above, occurs. The following delay events relate to the actions, or lack of action, on the part of the client, the contract administrator and/or the client's consultants, which may give rise to a ***contractor's claim***.

- Under the RIAI Contract: (a) architect's instructions; (b) late instructions; (c) delayed granting of possession of the site; (d) delays caused by the employer's direct employees, and (e) other acts of employer default.

- Under the Public Works Contracts: (a) change orders;(b) unnecessary opening up of works; (c) employer instructs a work suspension; (d) the contractor justifiably suspends work; (e) incorrect setting out information; (f) early partial possession; (g) late instruction; (h) failure to provide the contractor with access to works; (i) failure to provide a works item; (j) employers personnel delay the works; (k) rectification of work not damaged by contractor; (l) incorrect quantities; employer default. - The risk associated with (m) unforeseeable archaeology; (n) unforeseeable ground conditions; (o) uncharted utilities, and (p) unforeseeable delays caused by utility providers may be transferred to the contractor if the client is of the opinion that the contract documentation is sufficient to evaluate the risk.

If the contractor suffers loss and expense as a result of these events, he/she is entitled to submit a claim seeking reimbursement of the loss under the RIAI contracts, or use of the Programme Contingency under the PWC contracts. Prolongation (delay) and/or loss of productivity due the disruption of the regular progress of the works can be substantial. Contractors' claims often indicate that the client or one of the consultants has not performed their duties and responsibilities under the contract. Explaining the reasons for these claims can be embarrassing and difficult.

#### *Contract Administrator Issues*

The role of the contract administrator is arguably the most important appointment made by employers in commissioning building construction projects. The contract administrator acts on behalf of the client in administering the construction projects and carries out many of the day-to-day duties which would otherwise have to be performed by the client. The tasks and responsibilities undertaken are extensive and challenging. The role involves providing advice to the client, issuing instructions and information to the contractor, carrying out the administration and decision making functions in a fair and impartial manner in accordance with the contract conditions. The administrator must be capable of leading and motivating the various construction participants, who frequently have competing objectives, to achieve the common goal of delivering a successful project.

Problems are likely to arise if the contract administrator fails to perform these tasks, duties and responsibilities in a competent manner. Factors such as lack of experience

and technical knowledge, poor decision making, weak leadership and poor interpersonal and communication skills may all contribute to poor performance, which has inevitable financial implications.

### *Contractor Issues*

Chan and Kumaraswamy (1997) report that *clients* regarded ‘poor site management and supervision’, ‘inadequate managerial skills’, ‘improper control over site resource allocation’, and inadequate contractor experience as the four leading factors in causing delays on construction projects in Hong Kong.

The contractor’s primary obligations are to construct the works to the specified standard within the agreed project duration. In order to achieve these objectives the contractor must co-ordinate and motivate a team of diverse subcontractors some of whom may have been appointed by the client. Contractors may experience difficulties completing project on time for a variety of reasons for which they responsible. These include: inadequate or incompetent staff and/or subcontractors, poor productivity and inefficient execution of the works; poor analysis of the detail of the project in producing unrealistic programmes; coordination and communication problems; accidents; poor labour relations, and disputes.

A particular problem arises in cases where the contractor has submitted an under-priced or unreliable cost estimate. This may have occurred as a consequence of rushed tendering time frames, indefinite and uncompleted project scope, over-optimism, inadequate contingency due to poor risk assessment. Regardless of the cause of the under-pricing, the contractor will no doubt attempt to claw back more money than was originally agreed. While bad luck, under-priced work, and poor performance do not, *per se*, entitle contractors to additional payment, they do, as noted above, reduce the contractor’s profit. They are likely, therefore, to affect the contractors’ negotiating position in agreeing other areas of the final account.

## **Research into Construction Cost Performance in Ireland.**

In Ireland, significant cost overruns on public works projects in the period 1994 – 2004 led the Government to reform public sector construction procurement procedures. Cost overruns on particular civil engineering contracts completed during 2000 – 2003 averaged



an increase of 42%. The Comptroller and Auditor General stated that “*typically the price increase on such contracts would amount to 25% - 30% (with inflation in recent years adding some 10% – 15% to a project).*” The subsequent reform initiative led to the development of the Capital Works Management Framework (CWMF) and the introduction of the Government Contracts Committee for Construction (GCCC) Public Works Contract Forms, whose primary objectives are to secure cost certainty and value for money during the execution of the project (GCCC, 2014). It should be noted however, that cost overruns are a worldwide phenomenon, particularly on major infrastructure works, and that the Irish experience is by no means unique or exceptional.

### ***Brownlee (2005)***

Brownlee (2005) investigated the cost performance of public sector projects under the now redundant GDLA contract. He analysed data on 130 projects covering a wide range of building types with a combined value of €¾ billion (2004 prices). His analysis revealed that the final costs exceeded accepted tenders by an average 2½%. He observed that there were many reasons why the cost of buildings vary. These were ‘*often unpredictable*’, but in a small proportion of cases might have been foreseen or minimised. He noted that the swings and roundabouts that make up these averages more or less cancelled out overall.

Brownlee reports that some of the notable reasons for variations in cost were:

- Additional requirements, e.g. additional residential units, building fit-out;
- Net increase in sundry variations in details of construction (including adjustment of provisional sums);
- Problems found when existing buildings opened up; underpinning wall to street;
- Trial holes or information on underground services missed the full picture;
- Poor ground conditions; archaeology; contaminated soil;
- Where Contractor defaulted - vandalism between contracts and making good defective work of first Contractor;
- Wall and fencing to prevent dumping; additional security due to stone-throwing;
- Some Bill of Reductions omissions reinstated;
- Default of Nominated Sub-Contractors;
- Tenders for windows or restoration of stonework higher than prime cost provisions (in one window case there was no market);
- Only weeks of notice to have a builder on site;

- An arbitration case where the State body felt the award against them was very excessive.

The Report showed that deviation from the average is less for new-build and more for refurbishment/alteration.

***Hongtao (2014)***

More recently, Hongtao (2014) examined various causes of cost overruns on Irish building construction projects. He surveyed the opinions of 55 construction professionals representing a broad range of professional groupings. His respondents ranked various factors which may contribute to cost overruns on a scale of 1 to 3, where 3 was very important, 2 important, and 1 was less important. His results are set out in Table 1, following.

<b>Factor</b>	<b>Very Important</b>	<b>Important</b>	<b>Less Important</b>	<b>Weighting ex 3</b>
The complexity and scale of the project	36	18	2	<b>2.65</b>
The quality of the tender documentation	30	23	2	<b>2.51</b>
Poor design and project specification	25	30	0	<b>2.45</b>
The need for variations	10	40	5	<b>2.09</b>
The nature of the site	17	22	16	<b>2.02</b>
The choice of procurement option and form of contract	15	18	22	1.87
Inadequacy of provision for risk i.e. market and regulatory factors	6	20	29	1.58
Poor site management	5	22	28	1.58
The experience of the client	0	25	30	1.45

**Table 1 Factors which may contribute to cost overruns: (adapted from Hongtao, 2014)**

Hongtao (2014) considered factors with a mean score greater to or equal to two to be important. By his measure, the top five factors, shaded, were considered important and

the remaining factors to be less important. His respondents considered the complexity and scale of the project to be the most important factor contributing to cost overruns.

### *GCCC (2014)*

As noted above, cost certainty is regarded as a key objective of public sector project delivery and fixed price lump sum contracts have been identified as an effective means of achieving this aim. Fixed price contracts are most successful in delivering cost certainty where the design has been fully developed at contract award stage. The State has set a target that cost overruns should not exceed 1 to 2% of the contract sum. This is an ambitious target. The *Report on the Review of the Performance of the Public Works Contract*, (2014) found that the final accounts for some 532 building contracts were agreed at an average of 4.8% above the contract sum (GCCC 2014, Table 11).

Total Building and Civil Engineering Initial Contract Price €		Total Building and Civil Engineering Final Outturn Cost €	
1,216,180,902		1,305,087,592	
<b>7.31% Increase</b>			
Building Contracts		Civil Engineering Contracts	
Initial Contract Price €	Final outturn cost €	Initial Contract Price €	Final outturn cost €
354,483,581	371,388,716	861,697,321	933,698,876
<b>4.8% Increase</b>		<b>8.4% Increase</b>	

Table 11. Contract Price Compared to Outturn Cost for 532 Sample Projects

A further investigation of 312 of these project revealed that 1,451 Change Orders were issued on building projects with an average value €5,446 per Order amounting to a 3.08% increase in the contract value (Table 13 of the Report, below).

Building Contracts Change Orders			Civil Engineering Contracts Change Orders		
Number	Value	Av Value	Number	Value	Av Value
1,451	7,901,888	5,445.82	909	19,545,691	21,502.41
Percentage of Contract Value 3.08% <sup>23</sup>			Percentage of Contract Value 4.27% <sup>24</sup>		
<b>Overall Percentage of Contract Value 3.84%</b>					

Table 13. Change Order Values across Building and Civil Engineering Sectors

## Conclusion

Cost overruns are commonplace during the construction phase of building projects. This study has investigated common causes of cost overruns on building projects. It examines how the client's priorities and decisions regarding the project duration and quality expectations can undermine cost certainty. The actions of the client's consultants, particularly those of the architect / employer's representative, were identified as key factors in causing or preventing cost overruns. The building process, itself, is uncertain, particularly in relation to ground conditions. Large, complex and innovative construction projects containing a substantial element of specialist work were identified as ones which are particularly prone to cost overruns. The study outlined the impact of procurement decisions on cost certainty, noting in particular the likely response of contractors where under-priced work has been tendered and accepted.

Incomplete or poor design and poor tender documentation were identified as weaknesses which bring about the need to introduce an excessive number of variations. Similarly, failure to provide cover for excusable and compensable risks and market inflation may also lead to overruns. Poor performance of management tasks, administrative duties, and slow decision making were also discussed in the context of creating difficulties in controlling costs.

Avoiding cost overruns requires an effective plan which recognises these problems and exploits the ability of the quantity surveyor to effectively manage them.

## References

ARM4: Society of Chartered Surveyors and Construction Industry Federation (2009) *Agreed Rules of Measurement* 4<sup>th</sup> ed. Society of Chartered Surveyors and Construction Industry Federation, Dublin.

Ashton, P and Gidado, K (2001) *Risk Associated with Inadequate Site Investigation Procedures under Design and Build Procurement Systems*, on-line [http://www.arcom.ac.uk/-docs/proceedings/ar2001-961-969\\_Ashton\\_and\\_Gidado.pdf](http://www.arcom.ac.uk/-docs/proceedings/ar2001-961-969_Ashton_and_Gidado.pdf) Accessed [16th March 2017].

Brownlee, J. (2005) *Interim Report, Survey of Cost Performance of Building Work under the GDLA Agreement and Conditions of Contract for the Society of Chartered Surveyors*, Society of Chartered Surveyors, Dublin, On-line

<http://www.akc.ie/documents/GDLA%20Survey%20Interim.pdf> [Accessed 10<sup>th</sup> April 2017]

Chan, D. and Kumaraswamy, M. (1997), A Comparative Study of Causes of Time Overruns in Hong Kong Construction Projects, *International Journal of Project Management*. Vol 15, 1 p55-63.

Cunningham, D (2011) *Value for Money in Building Services under GCCC*, Unpublished Masters Thesis, Dublin Institute of Technology.

Cunningham, T. (2013), *Factors Affecting the Cost of Building Work – An Overview*, Arrow, Dublin Institute of Technology, on line: <http://arrow.dit.ie/beschreoth/27/> [Accessed 16<sup>th</sup> March 2017].

Cunningham, T. (2015), *Cost Control during the Pre-Contract Stage of a Building Project – An Introduction*, Arrow, Dublin Institute of Technology, on-line: <http://arrow.dit.ie/beschreoth/49/> [Accessed 10<sup>th</sup> March 2017].

Department of Finance (2008), *Training Manual TM-CC Public Works Contracts - Contractors*, Department of Finance, Dublin, on-line <http://constructionprocurement.gov.ie/wp-content/CWMFDocs/TM/TMCC.pdf> [Accessed 16th March 2017].

GCCC – Government Contracts Committee for Construction (2014), *Report on the Review of the Performance of the Public Works Contract*, Office of Government Procurement, Dublin, on line [Accessed 10<sup>th</sup> April 2017] <http://constructionprocurement.gov.ie/wp-content/uploads/Report-on-the-Review-of-the-Performance-of-the-Public-Works-Contract.pdf>

Hackett, M, Robinson, I and Statham, G (eds.) (2007) *The Aqua Group Guide to Procurement, Tendering, and Contract Administration*. Blackwell Publishing, Oxford.

Hongtao, S. (2014), *Preventing Cost Overruns on Building Construction Projects – An Investigation*, Unpublished Masters Thesis, Dublin Institute of Technology.

Hughes, W. Champion, R and Murdoch, J. (2015), *Construction Contracts – Law and Management* 5<sup>th</sup> ed. Routledge, Abingdon, Oxon.

Institution of Civil Engineers (1991) *Inadequate Site Investigation*, Thomas Telford, London, on-line <http://test2.ice.org.uk/getattachment/8a2addea-9c90-4be9-a663-f2378a98e226/Inadequate-site-investigation.aspx> [Accessed 16th March 2017].

Keane, D. (2001), *The RIAI Contracts – A Working Guide*, Royal Institution of Architects in Ireland. Dublin

Knowles, R. (1991) *Contractors and Subcontractor Claims the New Approach*, Seminar Proceeding Notes 4<sup>th</sup> December 1991 Jurys Hotel, Dublin,

Laryea, S. (2011) Quality of Tender Documents: Case Studies from the UK, *Construction Management and Economics* 29 (3) pp.275-286.

McCaffrey, J. (2010) What is an M&E QS? *RICS Construction Journal*, April May 2010 p.8-9.

McCaul, B. (2011) *Payment Clauses in RIAI Contracts & The Construction Contracts Bill 2010. Reducing Restrictions on Cash Flow & Improving Cash Flow*, Unpublished Masters Thesis, Dublin Institute of Technology.

Mitchell, C. (2016) *A Time for Change” An Evaluation of the Ability of the Quantity Surveyor to Measure Mechanical and Electrical Services Under the Irish Public Works Contracts (designed by the employer) using the Agreed Rules of Measurement*, Arrow Dublin Institute of Technology, on-line <http://arrow.dit.ie/beschreoth/61> [Accessed 21<sup>st</sup> March 2017]

Potts, K (2008) *Construction Cost Management Learning from Case Studies* Taylor and Francis, Oxford.

Rowland, H. (1981), *The Causes and Effects of Change Orders on the Construction Process*. Masters Thesis, Georgia Institute of Technology, Atlanta, on-line <http://hdl.handle.net/10945/20447> [Accessed 16th March 2017]

Sullivan, M. (2010) Let’s Get Technical *RICS Construction Journal* April-May 2010 p.8)