

The Quantity Surveyor: Missing in Action in the USA

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ABSTRACT: This paper examines why the British quantity surveying approach to measurement and contracting for construction work did not establish itself in the United States, given the close economic and cultural ties between the countries. The evolution of measurement at both locations up to 1800 is studied and the factors leading to the establishment of a separate quantity surveying profession in Great Britain during the nineteenth century are related. Towards the end of this century, as the American industrial revolution gathered pace and as competitive single price general contracting emerged, the issue of responsibility for the measurement of construction work was hotly debated. This culminated in a joint recommendation from the general contractor's and professional associations that a system similar to the British approach of using bills of quantities, be adopted. The paper concludes with reasons as to why this edict was never accepted by the American industry.

THE ROLE OF MEASUREMENT IN CONSTRUCTION

Measurement is required at every stage of planning, design, construction and occupancy and is particularly essential as prices are being calculated and as materials and labor are being ordered.

This requires a sound grounding in arithmetic and mathematics, a knowledge of design and construction, an understanding of contract law, a grasp of pricing and good negotiating skills. In the early days, measurement was often assigned to teachers of arithmetic (Adams 1985, p.385) or surveyors.

MEASUREMENT IN GREAT BRITAIN AND AMERICA UP TO 1800

As the focus of this paper is on the history of measurement and its use in establishing prices in the United States, its roots will be traced back to conditions and approaches used in Great Britain prior to and during the colonization of the North American continent.

The framework of the English construction industry was formed in the Middle Ages and this dictated who carried out the measuring and for what purpose (Nisbet 1993, p.10). The characteristics of the industry at this time were essentially the following:

- design and construction were carried out by the craft trades, primarily the masons and carpenters.
- materials were supplied and paid for by the owner
- reimbursements were frequent and based on either payment by the day, by measure valued at unit rates, or by a lump sum with agreed interim payments.
- the work was managed and coordinated by the client.

Under these circumstances, the trades bore most of the measurement responsibilities, especially where contracts were based on measure and value at an agreed unit rate(s). The client checked the accounts and this was often carried out on larger projects by a clerk of works.

There was little change in this method of working through the sixteenth century. By this time (1600) it would appear that the most prevalent method of contracting with the trades was by measure and value (Nisbet 1997, p.11) and it was this system that was carried to the first American colonies. It should be said however that

much building work there initially was housing and agricultural facilities of a simple character and much of this was performed on a fixed price basis for labor only, with materials supplied by the client.

Mid-seventeenth century England witnessed the emergence of the architect who became responsible to the client for the procurement of construction, coordination and management of the work, in addition to design. This included checking and agreeing the trade contractors' measurements and settling the final accounts. In conjunction with this responsibility there is much evidence of the growth of specialized measurers of construction work (Nisbet 1997, p.1). In keeping with other occupations at this time however, it was impossible for the most part, to make a living out of a single specialization. So the measurers frequently took on design work, surveying, acted as clerks of the works, sold building materials, or whatever it took to survive. The new independent measurers were in demand by the architects, the trade contractors and owners, such as the Crown, that had continuous construction programs. Demand for their services was particularly strong during the reconstruction of the City of London following the fire of 1666 (Baker 2000, pp. 4-7). This also led to the publication of the first books on measuring and pricing (Primatt 1667, Mandey 1682, Leybourn 1685).

In 1681 *Sir Christopher Wren* in a letter advising the Bishop of Oxford on contract choices, recommends "I think the best way in this business is to worke by the measure", but goes on to warn that this is conditional upon having access to good and honest measurers. He then states, rather condescendingly that ". I have bred up a few."

By 1700 therefore the acceptance of a distinct measuring occupation was well-established in England and Scotland. In the American colonies at this time, with a population of just 230,000 construction was still a rudimentary occupation, and the luxury of specializations was simply not feasible.

There was to be very little change in Great Britain until the end of the eighteenth century when the industrial revolution gathered pace and the Napoleonic wars began. The former created demands from the new industrialists and their financial backers for better prediction and control over construction costs and more rapid completion schedules. The British government was also under time and cost pressures in the construction of military facilities, especially barracks (Nisbet 197, p.31). The prevalent system at the time (measure and value by separate trades) relied on the determination of final cost only at completion and a relaxed linear schedule trade by trade. This was poised to change.

As the eighteenth century economy of colonial America matured, so the need for construction services became more acute. In large measure this need was serviced by immigration from Great Britain and other parts of Europe, all of whom brought their own method of working, which then collided with the realities of this new environment. By European standards, the distances were huge and transportation difficult, the weather extreme, the labor resources limited and the principle building material was wood with most of the rest being imported. The methods used therefore in designing and constructing needed to fit these constraints.

In colonial Virginia a common method of procuring projects was to advertise for an Undertaker. The *Virginia Gazette* between 1766 & 1776 carried 89 advertisements seeking proposals for various public and community projects: roads, marine construction, mills, churches, courthouses and the like.

The successful undertaker may have been selected on the courthouse steps and was often one of the local gentry who then laid off the design and construction work to carpenters and other trades. Any measurement activities fell to the trade. The owners did their best to verify the accounts, often resulting in disputes and the acquisition of poor reputations by the construction trades. On larger scale projects imported architects performed the same functions of project control they had learned in England, while complaining constantly about the quality of workmanship and materials.

No evidence can be found of the existence of any specialized measurers in the colonies, but enterprising individuals would offer services of this kind among others, as evidenced from an advertisement which appeared in the *Virginia Gazette* of August 3, 1772. A *J.Holland* and two compatriots recently arrived from London at Yorktown, VA offer a wide range of design and building services including ". . . to measure or convert timber,. . . measure and value any sort of work by trade.. ."

EMERGENCE OF THE QUANTITY SURVEYOR IN 19TH CENTURY GREAT BRITAIN

The concept of agreeing a single price and of contracting with one contractor was not unknown and was used widely for housing and other simple constructions. Driven by the client demands noted above, this approach started to be adopted for more complex buildings and by the first quarter of the 19th century was well established in Great Britain with firms of general contractors forming from the trades. This led to two major changes. First, in order to establish a firm fixed price before construction began, full details of the proposed construction had to be drawn and specified. Next the question arose as to who would measure the work to be carried out – the architect or engineer, or the new general contractor. The engineers solved the problem by acknowledging that much of their work was dependent on site conditions and that notional quantities of the work would be provided against which contractors would bid unit prices with the work being remeasured on completion. This approach continues to this day for most civil work involving earth- and site-work.

The architects, represented by the *Royal Institution of British Architects* (RIBA), however were in a quandary. Their fee (usually 5%) included measurement of the work post-contract and settlement of the final account. Their clients now expected them to prepare a full set of designs and a schedule or bill of quantities, to be used by the tendering contractors. They were not happy to take on responsibility for this type of work without additional reimbursement. On the other side the general contractors, who were invariably bidding in competition,

believed they should all be given the same quantities or be paid to have them taken off. The measurers for their part were only too happy to oblige either party as long as they were paid for their effort.

For most of the nineteenth century in Great Britain a compromise was worked out whereby the contractors were provided with a bill of quantities by the architect, either measured by them or by an independent measurer, with instructions that the cost of preparation was to be included in each of the bidding contractor's prices. The successful contractor would then pay the architect or measurer for the bill after receipt of the first payment from the client. In other words the client was paying for the quantities without, in most cases, realizing it.

Meanwhile the measurers had become Measuring Surveyors and from the 1850's the term Quantity Surveyor begins to appear. Around this time many of the well-known firms of quantity surveyors had their beginnings. They were quite comfortable preparing bills of quantities for architects or for contractors. They were not recognized by the architects, who clearly intended to maintain their leadership position in the industry. The RIBA banned architects from preparing quantities on anything other than their own projects. This was widely ignored as production of the bills delivered a lucrative fee in the region of 1 to 2 ½ %, plus reimbursement for post-contract adjustments for changes.

The quantity surveyors belonged to the *Surveyor's Institution* (SI) formed in 1868. This included all kinds of surveyors: land, mining, valuation, building and even auctioneers. Many architects were also members. The quantity surveyors had little influence inside the SI and were actively ignored by the RIBA with the result that their public recognition was non-existent. An attempt in 1889 to obtain a stronger say in the affairs of the SI was rebuffed and this led in 1903 to the formation of the *Quantity Surveyors Association*.

By this time there had been a significant change in the role of the bill of quantities driven by demands of the general contractors. The first issue concerned a guarantee of the quantities provided. If a contractor was to rely on their accuracy and there were errors or omissions, it seemed unreasonable that the contractor would suffer the loss exclusively. Three approaches (Nisbet 1997, pp.80-81) were tried:

- the contractor was required to verify the quantities before signing the contract
- a quantity surveyor would be retained who agreed to guarantee the quantities
- two surveyors were employed to produce a jointly agreed bill.

The next step was to make the bill of quantities a contract document with contract clauses which allowed adjustment of errors and omissions, the use of the document for payment purposes and as a basis for the valuation of changes.

By 1910 the *Institute of Builders* recommended that its members refuse to tender on any project valued over £500 without a bill of quantities being provided (Nisbet 1997, p.109). Finally the quantity surveyor had arrived with a clear recognized role. Even then the architect's retained control over the appointment and payment of the quantity surveyor. It was not until post-World War II that they established themselves as an equal member of the British construction scene.

THE UNITED STATES UP TO C.1900

Meanwhile in the new United States the pressure experienced in Great Britain to move to a single price general contracting system was delayed until the last quarter of the nineteenth century. The Federal government had attempted in the 1850's to obtain single prices for custom- and court-houses (Lee 2000, p.51), but abandoned this approach when a new Supervising Architect, *Alfred B. Mullett*, was appointed. Work continued to be awarded on a trade by trade basis. Much of this work was contracted on a lump sum basis or the same measure and value approach used in Great Britain. It was the architects and engineers who checked the trades' quantities and dealt with procurement and contract issues. There is still no evidence of a separate measuring profession gaining ground at this time.

Once the Civil War was over the American industrial revolution gathered momentum and circumstances changed, much as they had in Great Britain. The new industrialists and their financiers sought price guarantees for their projects before construction began. The period also saw the emergence of a new type of client, the property developer, who similarly expected firm prices before embarking on their speculations. The public sector, dealing with larger and more complex projects which frequently exceeded their budgets, was also seeking a different approach to contracting their work.

In response general contractors began to appear from about 1865 stepping up to take on the risk of a single contract and to guarantee a fixed price. Firms such as the Norcross Brothers, James Stewart & Company, George A. Fuller & Company were established (Wermiel 2006, pp. 3297-3330). They came not just from a trade contracting background (usually masons or carpenters), but also from engineering and architecture. The same issues that surfaced in Great Britain concerning responsibilities for measurement reappeared. The architects, who had post-contract measurement obligations, balked at producing a pre-contract bill of quantities for bidding purposes, leaving the general contractors to their own devices.

The civil engineers took the same approach as their British counterparts. Civil work was unpredictable and could not be bid on a lump sum basis. Therefore a schedule of unit prices was bid based on quantities provided by the engineer, subject to remeasurement on completion, except for those elements, such as bridges, where designs were finite.

It was therefore in building work that the confrontation over measurement was played out. It did however take some time to resolve as general contracting and separate trade contracting existed side-by-side well into the first quarter of the 20th century. The early general contractors were either self-contained with all key building trades employed directly by them (e.g. Norcross Brothers), or they relied on subcontracting the bulk of the work out to separate trade contractors (e.g. George A. Fuller Company). In the first case the contractors employed their own estimators to measure the quantities for bidding and construction purposes and, while they may have used part-time quantity surveyors, had no real need for a separately produced bill of quantities. For those relying on subcontractors the burden of the quantity take-off work was defused through each of the trade entities, who had acquired expertise in estimating for their own account. As a result the first record that can be found of any published discussion of introducing a quantity survey into the bidding process is an article by a Mr. G. Alexander Wright (who will appear again in the narrative) on the subject in the *American Architect & Building News* of January 23rd 1897.

THE QUANTITY SURVEY DEBATE 1913 – 1922

As general contracting became more prevalent drawing in smaller firms who were thinly capitalized and the use of the single price contract spread, the issue of providing quantities with the drawings and specifications began to receive wider attention. The issue focused on the duplication that occurred from requiring every bidder to measure the same quantities. This was particularly acute as only the successful contractor would obtain reimbursement of its estimating cost to which would have to be added the cost incurred in preparing unsuccessful bids. The argument therefore was that the owner was paying for costs incurred on projects other than his own and would it not be better and cheaper if he was to arrange to have the quantity take-offs, the largest cost in estimating, provided to all bidders?

The first of many articles appeared in the *American Architect and Building News* of 1913 written again by G. Alexander Wright (Wright 1913, pp200-202). He was a member of the AIA and must have been a British immigrant, as he also held memberships in the *Quantity Surveyors' Association* and was a Licentiate of the RIBA. In the article he points out most of the arguments put forward subsequently as the debate expanded:

- the obvious saving of duplicated effort mentioned above.
- that all bidders would be estimating their prices based on identical quantities.
- the likelihood that the quantities will be more accurate when measured by a professional.
- that any errors or omissions would be fairly adjusted if the quantity survey was a contract document.
- that the civil engineers were using the system and had been for generations.
- that pre-bid measurement by a professional would eliminate most of the ambiguities between drawings and with the specifications.
- that costs were likely to be reduced not only from lower bidding expense, but also from the elimination of contractor contingencies.

Articles followed in the *Journal of the American Institute of Architects* (Cross 1914, pp.20-24) which made it clear that the Architects were in favor of introducing the quantity survey paid for by the client, although they did point out some of the implementation problems and were especially concerned as to how the quantity surveyors were going to be recruited. By 1914 the AIA had set up a Committee on Quantity Survey to examine all aspects of the system. They reported in the *Journal* of September of that year that four projects, in San Francisco, Wilmington, Boston and Portland, had used quantity surveys. The writer was found records of the Wilmington project, a Municipal Building for the City conjoined with a building for Newcastle County, which is reviewed at Appendix I.

The AIA's archives of the Committee on Quantity Survey are rather sparse, but do include some interesting letters. One from the *Province of Quebec Architects Association* asking for information and another from The Quantity Survey Co., Inc. of New York enclosing a booklet of their services, indicating that at least one independent firm was in operation. This was the same company that provided the quantity surveys for the Wilmington project.

Articles continued to appear annually in the *American Architect* and the *Journal of the American Institute of Architects* on the subject. Notably absent is any opinion from owners, who appeared unimpressed by the arguments in favor of quantity surveys and certainly resistant to paying any extra fees for their production. In 1917 a National Conference Committee to consider the Quantity System was formed with representatives from the AIA, various engineering societies and contractor organizations. The *Associated General Contractors of America* (AGC) was formed in 1918 and the discussions continued.

Meanwhile over this period, the contractors were not idle. No doubt sensing that client or architect supplied quantity surveys were somewhere in the future, there were several attempts at the local level to address the issue. These were focused on payment to contractors to ameliorate the costs of abortive estimating on unobtained jobs. Two methods were introduced: the Nelson Form and the Kelley System, named after the people that ran the organizations that supported them. Both approaches are detailed in the *American Architect* of September 24th 1919, but in summary they both had the following characteristics:

- A schedule of percentage charges for estimating according to project value was set up.
- Each contractor added to his bid price a sum equal to the percentage value times the number of bidders as communicated to him by the organizers.
- After the contract was awarded the successful contractor paid to the organizer the sum included in his bid.
- The organizer deducted a commission and then paid out the balance to all bona fide bidders.

Various safeguards were put in place to discourage unscrupulous contractors from putting in cover prices just to collect the fee. The owners therefore were paying for the estimating effort of all bidding contractors, although they probably did not realize it.

The second approach used by the contractors was to establish a Bureau of Quantity Survey at a local level which provided the quantities to every bidding contractor belonging to the Bureau. These began to gain ground once AGC chapters were formed around the country.

By 1921 the AIA, AGC and the *Federated American Engineering Societies* had reached agreement on a joint position concerning Quantity Surveys and this was issued in 1922 under the title "Eliminating Waste in Estimating: Quantity Survey and Payment for Estimating. Procedure Recommended to Owners and Investors, Architects, Engineers and Contractors". It included two pages of text justifying the recommendations, which were:

- Architects, engineers and contractors should jointly use their efforts to have established facilities for making quantity surveys.
- The owner should pay for the quantity survey from 0.25% to 1.00% of the cost of the project.
- The owner should have the option of making the quantity survey a part of the contract, or permitting the successful bidder, at his own expense, an opportunity to verify the accuracy of the document.
- No guarantee of the quantities by the quantity surveyor should be provided for fear the surveyor would increase the quantities for protection.

This document received a fair amount of publicity, most of it favorable, but as was pointed out in Saylor (Saylor 1957, p.60), "With all this heavy sponsorship, it seems surprising that the recommendation made such a little ripple in being sunk without trace".

FROM 1922 TO THE FINAL COUP DE GRÂCE IN 1945

It seemed as if, having made the recommendation after all those years of debate, that each of the institutions went its own way, especially as the owners showed no interest in paying for a quantity survey that they seemed to think was just an industry problem.

One small group that remained enthusiastic was, naturally, the quantity surveyors. They had formed themselves into the *American Institute of Quantity Surveyors* (AIQS) in 1926, no doubt in anticipation of an avalanche of work. Unfortunately no records of the AIQS seem to have survived. The members appeared mostly to have marketed their services to the general and trade contractors, but also to the architects for whom they prepared pre-bid cost estimates.

More AGC chapters began to form Survey Bureaus and the first of these operated successfully in Milwaukee, WI for many years from 1914. This seemed to have been organized by the branch itself, which employed quantity surveyors directly to do the measuring. The Bureau charged at rates from 0.20% to no more than 0.50%. Each bidding contractor who made use of the quantity survey, included the fee in the bid with the successful bidder paying the Bureau. *R.L.Reisinger* from Milwaukee reported at the AGC convention of 1924 (*American Architect* 1924, pp. 217-8) on the financial viability of their Bureau, citing its healthy condition with surpluses that were used for a variety of purposes, including funding two dinners per month for the branch! By the conventions of 1927 and 1928, the *Constructor* magazine (*Constructor* 1927, p.32) reported that Quantity Survey Bureaus were in operation in St Louis MI, Portland OR, Birmingham AL, Philadelphia PA, Detroit MN, Texas, North Carolina, Boston MA and Hartford CT, with many others being considered. Some of these Bureaus were 'commercial', i.e. not owned and operated by the AGC branch.

Two factors brought an end to them. First in 1930 the Depression arrived and in the following years decimated the economy and the construction industry. Then the independently operated bureaus began to offer, at an extra charge, prices in addition to quantities with recommended bid amounts. This did not sit well with the reputable contractors, especially when the Bureaus began selling their goods to incompetent firms. On top of this they acquired reputations for inaccurate work. This was laid out in a letter from *Ward P. Christie* of the AGC to *E. C. Kemper* of the AIA dated May 9th, 1930 in which he questions the AGC's commitment to the 1921 recommendation due to the irresponsibility of the independent survey bureaus, the mistrust of contractors in any quantity survey that they did not prepare themselves and he raises another interesting objection: "Contractors have discouraged the supplying of surveys by owners because they do not want to drift into the system of unit price bidding on buildings, and because the average owner uses little discretion with respect to distribution of the survey". The letter goes on to explain modifications to the Kelley system then being used by several chapters.

Finally, many years later in May 1945, at its executive committee meeting in Chicago, the AGC withdrew its support of the 1921 recommendation, stating in a letter to the AIA, ". . . deciding that the document has outlived its usefulness, and should not be republished with A.G.C. endorsement". By now most general contractors had come to value their estimating departments, realizing that the act of measuring and pricing gave an im-

portant insight into the project that was to be built and a vital part of the competitive process that was involved in acquiring contracts. In the post-war period general contractors moved further away from carrying out any part of the construction work, relying more on sub-contractors. Their expanding management role on projects increased their need for better pre-construction cost control, further enhancing the role of their estimating divisions.

Some architects expanded their own cost management skills or, as was more likely, relied on a growing cost consulting profession to keep their projects within budget. Many of the new cost consultants drew on British and other Commonwealth quantity surveyors for staff. Beginning in the late 1950's English quantity surveying firms, somewhat belatedly, began to establish themselves first in Canada and in the 1960's in the United States. Many have now grown substantially and broadened their services to include a wide range of project control and management services. How different the landscape of the American construction industry might have been had they seized this opportunity after the First World War.

CONCLUSIONS

So why was it that the logical process of events that occurred in Great Britain that led to the establishment of a Quantity Surveying profession there, was not repeated in the United States? In England a rudimentary measuring profession began in the mid-17th century and grew steadily with the prevalence of measure-and-value as the preferred contracting approach. Measurers (proto-quantity surveyors) were therefore in much demand and the system formed the basis of what was to follow. These conditions never developed in the United States and several other factors mitigated against the formation of an independent profession.

- Prior to the emergence of single price general contracting in the late nineteenth century, independent measurers were unknown in the United States.
- The architects resisted pressures to supply a quantity survey insisting that the owners pay an additional fee. The sleight of hand used by the British architects whereby the fee was tucked into the contractor's bid, presumably eluded the American architects as a solution or was considered beneath their ethics.
- The owners were indifferent to the arguments in favor of quantity surveys, considering it an internal industry matter.
- The general contractors, who in theory had the most to gain, simply coped with the problem themselves with cost-sharing systems and measurement bureaus. Along the way, they learned that in-house estimators were an important asset and they decided they did not care to have their internal pricing open to all. The single price contract with minimal breakdown afforded considerable commercial advantage and placed them in a stronger position in their relations with the architect and the owner.

EPILOGUE

In both countries today, the tedium of measurement is increasingly being taken over by digitizing and automated systems. In the UK the quantity surveying profession is in transition from measurers of quantities to cost and contract managers, even to project managers. Those employed by contractors, now act as commercial managers.

In the US there is a growing body of independent cost consultants and professional construction managers emerging. Contractors in the meantime are expanding their services to the owners with a wide range of pre-construction services.

So, while the nomenclature may be different, there is a degree of convergence taking place between the two countries. As to which of them benefited most from the directions it took, it is left to the reader to judge.

APPENDIX I

Municipal & Newcastle County Building, Wilmington, Delaware

A five storey public building to house the courts, city and county offices, the city council chambers and police station. The building is clad in Webb pink granite from Milford, Massachusetts; it is steel framed with fine quality interiors. The budget was \$1,025,000 excluding land purchase; final cost was \$1,250,935. The building was opened in 1916.



Figure 1: Wilmington and Newcastle County Public Buildings, Wilmington, DE.

The Architects

The project was initiated in 1913. After an architectural competition, John Dockery Thompson, Jr. (a local architect) and Palmer, Hornbostel & Jones (PHJ) of New York (associated architects) were appointed and their contract is dated March 31st, 1914. There are 15 clauses, the most interesting for our purposes, being their scope of work (design, procurement advice and management, supervision of construction), preparation of drawings and specifications for either a general contract or separate trade contracts, and a fee of 6% plus additional costs for structural steel and heating, ventilating & electrical design, and a permanent clerk of works.

Construction

The method to be used for contracting must have been discussed immediately. Unfortunately none of the day-by-day correspondence has survived, but a contract was awarded on June 17th, 1914 for excavation and clearly a decision had been taken to proceed with separate trades. Further it was also decided to employ a quantity surveyor to prepare quantity surveys for all of the major trades. This was one of the first applications in the country and it attracted a fair amount of notice. There is no record of the reasons for doing this, but here are some thoughts:

- The City and County were anxious to provide as much opportunity as possible for local contractors and workers. A project of this size would almost certainly have attracted general contractors from Philadelphia, Baltimore and Washington who would probably bring in trade contractors from those locations.
- By taking a separate trade approach work could begin immediately.
- Henry Hornbostel was the chair at that time of the AIA sub-committee investigating quantity surveys and would have seen this project as a demonstration of the system.

The Quantity Surveying Experiment

On July 9th 1914 a contract was signed with the Quantity Survey Company, Inc. of New York for the furnishing of a complete list of quantities for twelve specification divisions: Plumbing, Masonry, Concrete, Cut Stone, Heating and Ventilating, Electric Wiring, Metal Furring and Lathing, Glass and Glazing, Plastering and Imitation Stone, Metal Doors and Trim, Window Frames and Sash, Carpentry and Cabinetwork. These trades probably represented about 60% of the work.

The contract guarantees the accuracy of the quantities to within three percent and a surety bond is attached to the contract to back this up. There was a fixed price fee of \$5,000.00, plus 2% for any extra works that needed to be measured. The contract was for quantities only, i.e. no pricing, no checking bids, or no payment certification.

The Bills of Quantities (BQ) themselves are very detailed. For example the Plastering Bill has 70 priced line items. Items are referenced back to the specifications and to individual drawings. The BQ for the Stonework lists every stone separately by size and character and extends to over 40 pages. The preliminaries state that the work is

measured 'in-place' and that no allowance has been made for waste. No other measurement conventions are given, for example, stating how deductions have been made for openings. It would appear from the archive that there were no serious problems with the trade contracts arising, either during bidding and award, or during construction and the approach must have been deemed a success.

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