Not just the dirty work: engineers' contributions to architecture

David Yeomans
Independent scholar

Introduction

The sociologist Everett Hughes used the phrase 'the dirty work' to point out that in many areas of work there are those who enjoy prestige in the practice of their profession but who rely upon the work of others to carry out routine tasks – the dirty work [1]. Those who enjoy prestige, and the salaries that go with it, could not practice effectively without those who do the menial work work. An obvious example is the relationship between hospital doctors and the nurses - the latter not expected to make any clinical decisions over the care of patients even if, because of their constant observation, they might be in a position to know as well as the doctor what care was required.

The division we are concerned with here is between architects and structural engineers and the extent to which the latter are simply carrying out the dirty work or might have been able to influence the architectural form. The latter might happen in one of two ways: engineers might collaborate with architects over particular projects perhaps suggesting structures that the architect might not otherwise have considered or engineers might develop forms which architects might then adopt. The latter is easier to observe unlike the former, where individual engineers collaborate closely with individual architects. The questions here are firstly to identify when such collaborations have occurred and secondly to ask what conditions enable collaboration to take place.

When steel and reinforced concrete frames came into use in building it was engineers who were asked to carry out their detailed design because that was beyond the competence of architects. However, the division of responsibility between the architect and the engineers was made clear by an architect writing in 1914 who said that 'It is the architect, and the architect alone, who should determine the position of all main girders, stanchions and supports.'[2] Clearly, no true collaboration between the two professions was expected in the development of the design; engineers were simply to work out the sizes and the detailing of structural members.

However, the position seems to have changed by the 1950s when Furnaux Jordan, writing about the collaboration between Ove Arup and Architects Co-partnership for the design of the Brynmawr factory, said:

> 'Much of the merit of the Brynmawr factory in design and execution- is due to the extraordinary close co-ordination between engineering and architecture … the engineers understood throughout the aesthetic aims of the architects and themselves made an aesthetic as well as structural contribution.' [3]

The factory was based on a series of shells, novel in Britain at the time, so one might not expect the architects to initiate the idea because they would have had little knowledge of what was possible. How then did this change take place and what effect was it to have?

The inter-war period

Much of the structural design work in the inter-war years was carried out by contractors rather than by consulting engineers. Architects would decide whether a framed building was to be of steel or reinforced concrete and put the work out to tender. Those bidding for the work would then have to carry out at least sufficient design wok to be able to put in

a price, which would have to absorb the design costs including those of unsuccessful tenders. These circumstances hardly encouraged contractors' design staff to provide any more than the most basic structures, designed as well as built most cheaply. There were consulting engineers but if the job book of B.L. Hurst is typical they might work for contractors as well as architects carrying out design work that was beyond the capability of those in contractors' offices [4].

Perhaps the first public acknowledgement architecture as a possible collaboration with engineers was by Harry Barnes reviewing the work of Owen Williams and Maxwell Ayrton for the Empire Exhibition buildings.

> Theirs was the marriage of true minds to which there has been no impediment . . . [T]hey have shown the possibility of collaboration and co-operation between architect and engineer each enhancing the work of the other [5].

Sadly however this was a marriage that was not to last. Williams worked as a bridge engineer and worked with Ayrton on bridge designs, particularly those for the A9 road in Scotland which produced some interesting designs. However, when it came to building work with Ayrton things did not go well. They did three buildings together but none made any expression of their concrete structures. Although the warehouse for Pilkingtons designed by Ayrton, with structure by Williams, was described as 'impressive' and a carefully considered work, the elevations proclaimed it to be a brick building in spite of its reinforced concrete frame [6]. Eventually when Ayrton chose to speak at the RIBA on the aesthetics of bridge design there was a rather public break between the two [7].

Williams made an impressive contribution to the Daily Express building, with Ellis & Clarke as architects. There he obtained the commission because he was able to show how to support an existing building above the basement, which housed the presses, increasing the space available by building a concrete structure to carry the existing steel frame above. However, it is clear from his surviving drawings and reports at the time that he did more than that. The building had to cantilever over Shoe Lane to provide a bay for unloading the paper deliveries and the change from the structure of the basement press-room to accommodate the planning of the floors above involved a 2ft reduction in span. Chermayeff's review of the building was fulsome in praise of Owen Williams's contribution to the design [8].

What was more striking about the Daily Express building was the contrast between an early Ellis and Clarke sketch and the final treatment of the building. Their early sketch might be described as 'Fleet Street bombastic' but In the event the building had a modern curtain wall, which is said to have been the idea of Bertram Gallannaugh [9]. While the structure provided by Owen Williams must have had a considerable influence on the overall form of the building we have no idea how much he might have contributed to its external appearance. However, he certainly took an interest in the treatment of the curtain wall because there are sketches for it in the Owen Williams archive that show his engagement with the idea [10].

Owen Williams was then given the commission as both architect and engineer for the paper's Glasgow and Manchester buildings. He seems to have directly copied Ellis and Clarke's details for the cladding for those buildings but at Manchester there was no temptation to have the framing expressed in the cladding because he used flat-slab construction with the columns set back behind the facade. In fact the view from the street to the press hall below required uninterrupted glazing.

Williams adopted flat slabs in other buildings where he acted as architect as well as engineer. His best-known building was the Wets Building for the Boots pharmaceutical company, which used a development of the flat slab, and he used flat slabs in his Pioneer Health Centre. But this device was already making its way into British architecture via another route for commercial buildings. We see this particularly in the Wrigley Factory by Wallis Gilbert and Partners whose structure was designed and built by the Trussed Concrete Steel Company [11]. The client was an American firm requiring this American structural system, slow to be adopted in Britain because it did not fit into the reinforced concrete

regulations. Nevertheless, it was being used by contractors in Britain for commercial and industrial buildings as William Arrol's office handbook shows [12].

A contemporary of William was Oscar Faber but his engagement with architects and architecture is a little more enigmatic. He began work with Trollop and Coles with an agreement that he could take on his own consulting work. Then an important client was Herbert Baker with whom he not only provided structural advice but also the designs for the services at the extensions to the Bank of England. Subsequently the design of building services became an important part of his business, which in 1937 provided the service design for the Earls Court Exhibition Centre, designed by the American architect C. Howard Crane [13]. His partner in this was J.R Kell with whom he produced a textbook on heating and air conditioning, which has remained a standard work to this day [14].

As a designer of many industrial buildings Oscar Faber was concerned with their appearance, eventually giving lectures on the subject to the Institution of Civil Engineers [15]. Thus, he might well have felt that he could have made more of a contribution to architecture than he did. When writing on engineering for students of the Architectural Association he advised them to engage an engineer as early as possible in the design process [16]. Nevertheless his only notable work where we see a possible influence on architecture was the structure he provided for the Royal Horticultural Hall in London with architects Easton and Robertson. As Faber subsequently used a similar design for a market hall in Nairobi, one wonders how much influence he might have had on the London building's form.

We have the clearest indication of engineers' engagement with architects in the work of Ove Arup and Felix Samuely. Arup's early work with architects developing novel forms of construction was with Lubetkin and Tecton in the design of flats [17]. Beyond that his articles in *Architectural Design and Construction* may well have influenced other architects [18]. What he proposed for reinforced concrete buildings was a structural arrangement that eliminated the regular grid of beams and columns.

Samuely had made his mark in Britain with the structural design for the De La Warr pavilion, which was the first major building in Britain to be in welded steel. This was doing 'the dirty work' because the form of the building was decided by the competition entry, which the architects had designed on the mistaken assumption that it could be built in reinforced concrete. What they wanted would have been impossible in reinforced concrete but Samuely managed to show how it could be achieved in welded steel.

Samuely had developed a reputation for welded steel design in his practice in Berlin [19]. His later welded structure for Simpson's Store, Piccadilly may well have influenced the design because a deep vierendeel girder was designed to avoid columns within the display windows at street level. Unfortunately the LCC would not approve the design and deep plate girders had to be provided at every floor. This must have been an expensive arrangement and it is possible that a more conventional arrangement with columns in the window space would have been used had the LCC's objections to the original design been known earlier.

His work in reinforced concrete for Wells Coates was equally impressive. Wells Coates made his mark architecturally with the Lawn Road Flats that can reasonably claim to be the first Modern Movement building in Britain. It was a series of single room apartments, each with a small kitchen and bathroom. For that he had used contractors, the Helical Bar Company, to provide the structure, which was a simple frame resulting in columns in the corners of the apartments [20]. However, it is clear from the plan that walls could have been used. Coates then designed a major apartment block, Embassy Court, on the Brighton and Hove seafront with Samuely as structural engineer. For that Samuely intended to use a Hungarian system called Diagrid to avoid downstand beams within the flats but the local authority would not approve it. In the event he used a spine beam layout, where this beam was placed over cupboards built at the back of the living room framed by columns placed next to door openings. Wind loads were transmitted through the floors acting as diaphragms to where there were walls enclosing staircases.

Coats's subsequent Palace Gate Flats would not have been possible without the structural designs by Samuely, which used walls as beams to handle the complex interlocking nature of the apartments. Certainly that could not have been achieved with a simple beam and column structure. Had WWII not intervened this system would have been used in a development of working class flats.

Post-war

The practice of engaging consulting engineers became more common in the immediate pot-war period because of the shortage of materials and the need for post-war reconstruction [21]. Collaboration with engineers would have been encouraged by the appearance of new forms of structure that architects were less comfortable with, such as the shell structures of the Brynmawr factory, and this provided a much greater opportunity for collaboration. Ove Arup was naturally one who was seen to work in that way.

While we have Furnaux Jordan's report of this particular job by Arup there are no reports of his work with other architects that suggest this degree of collaboration. Neither did he try to influence architectural design through publications as he did with his 1935 article. However the formation of what began as the building group within his practice, which then became Arup Associates, is an indication of his commitment to architecture. This was led by Philip Dowson who had originally gone to Cambridge to read mathematics but later studied architecture at the Architectural Association, joining Ove Arup and Partners in 1953. Arup Associates integrated architects, structural and services engineers within a single firm, a pattern that had also developed in the United States.

Interest in architecture within Arup's can also be seen in its seeding of Bureau Happold and the team that won the competition for the Centre Pompidou. While Ted Happold left Arups to found his own firm, Peter Rice, who was the principal figure in the design of the Centre Pompidou remained with Arup's to work closely with a number of major architects on international projects. While André Brown has reproduced a few of Rice's sketches to illustrate his very visual method of working and communicating it is a pity that there are not fuller accounts of the development of his designs illustrated by his sketches [22].

There is much more indication of Samuely's involvement with architects than of Arup's staff. Malcolm Higgs reported that 'It was his practice to sketch a number of alternative structural solutions and to encourage the architect to make the final decision, as to which one was to be pursued.'[23] When he reported on the design for the Skylon at the Festival of Britain, a winning competition entry, he commented on how it was unusual for him to be presented with a completed design, suggesting that engaging in the early design process was more normal for him [24].

He also produced a number of articles promoting such ideas as folded plate structures and star beams. He used folded plates in a number of buildings such as the Thomas Linacre College and a school at Kingston on Thames where he used precast elements as permanent formwork for insitu concrete to form folded plates to span the length of the assembly halls. But it might have been his promotion of this form in publications that had the greatest effect. Of course we have no data that will tell us how many designers were directly influenced by his publications.

A number of significant building were designed by Samuely in precast concrete and while an extensive history of precast concrete has been produced by A.E.J. Morris, his account of post-war Britain largely begins with the period when tower cranes made the handing of precast units relatively simple [25]. He does not deal with the immediate post-war years when the best a contractor could hope for was a Ruston-Bucyrus 22RB with a crane jib mounted on it. It was using such equipment that Hatfield College was built, with Felix Samuely as structural engineer (Fig. 1)[26].

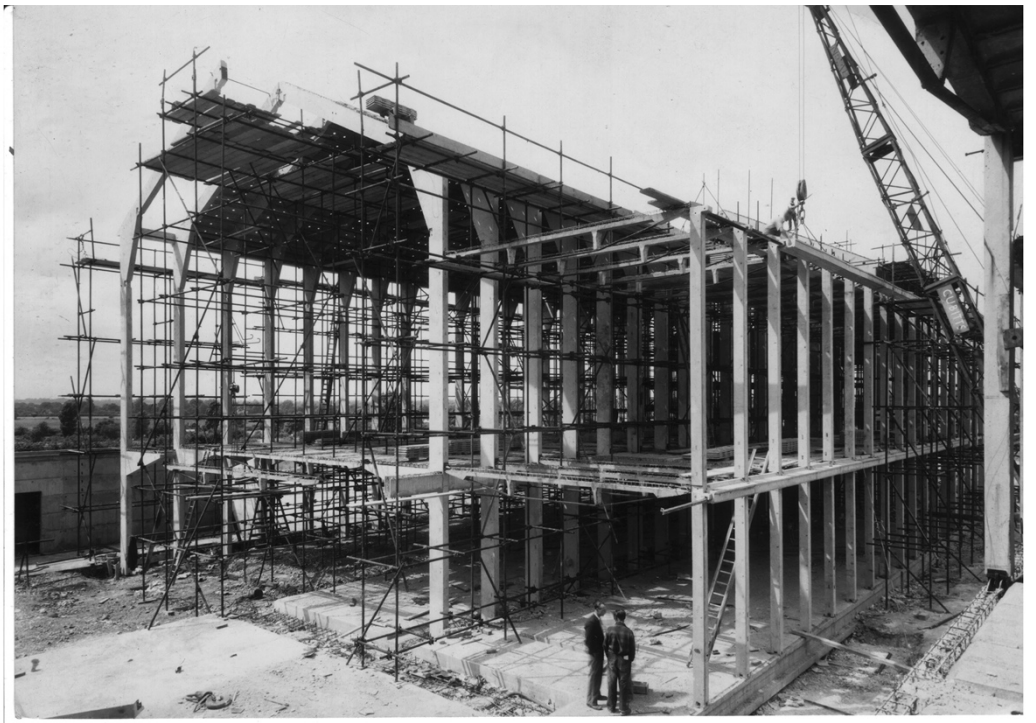

Figure 1: Hatfield College under construction

Samuely also devised a precast wall system in collaboration with Grenfell Baines, used first at Thomas Linacre College, Wigan. But perhaps his most influential collaboration was with Frederick Gibberd for the Dock Labour Board building. Given the detail of the drawings produced for that building we must surely assume a considerable involvement by Samuely in the development of the scheme (Fig. 2). Samuely's more daring use of precast concrete was the frames for the Malago factory at Bedminster, Bristol. Of course, precast concrete was subsequently developed for cladding and load-bearing wall systems, but these early framed structures deserve more recognition than they have received and they rely upon engineers' involvement.

The engineers that then came out of the Samuely stable and were influenced by his method of working were Frank Newby and then in turn Tony Hunt. Newby must have learnt his method of working from Samuely because important collaborations occurred very early in his career when he travelled in America. He spent time in Eero Saarinen's office where he was able to suggest a method for handling the structure of the Milwaukee War Memorial [27]. He also visited Wallace Harrison when he was designing the First Presbyterian Church of Stamford, Connecticut. The sketches for the original design were published in Architectural Forum and bear no relation to the final design [28]. It is clear that Newby must have suggested the folded plate design finally adopted by Harrison because it resulted in Felix Samuely's only job on American soil.

A better picture of Newby's engagement with an architect can be found in a series of sketches sent to Spero Daltas for buildings in Iran. As the two were working at a distance Newby sent sketches with written comment to Daltas to develop the design (Fig. 3). The two buildings built following this exchange were a Coca-Cola bottling plant and a garden building for Princess Fatima, both constructed of brick vaulting on steel armatures. One can readily imagine that the contents of his letters reflected the kind of conversation that Newby would normally have had with architects on a face-to-face basis [29].

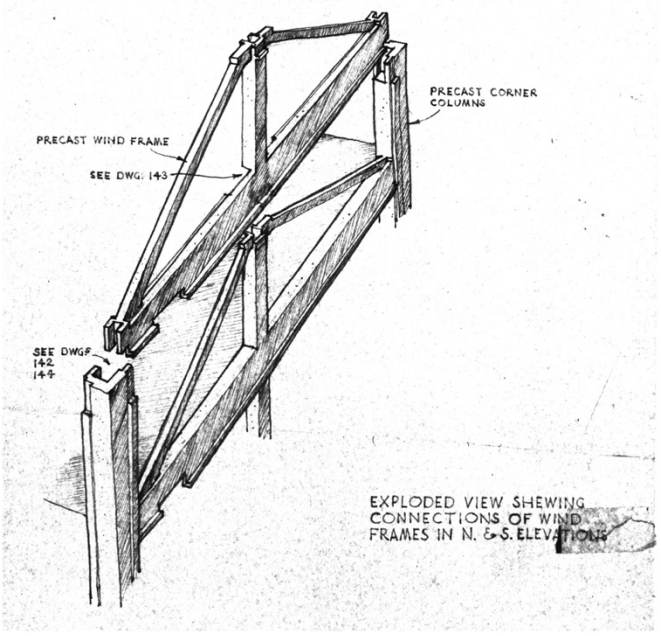

Figure 2: One of a number of assembly drawings for the Dock Labour Board building

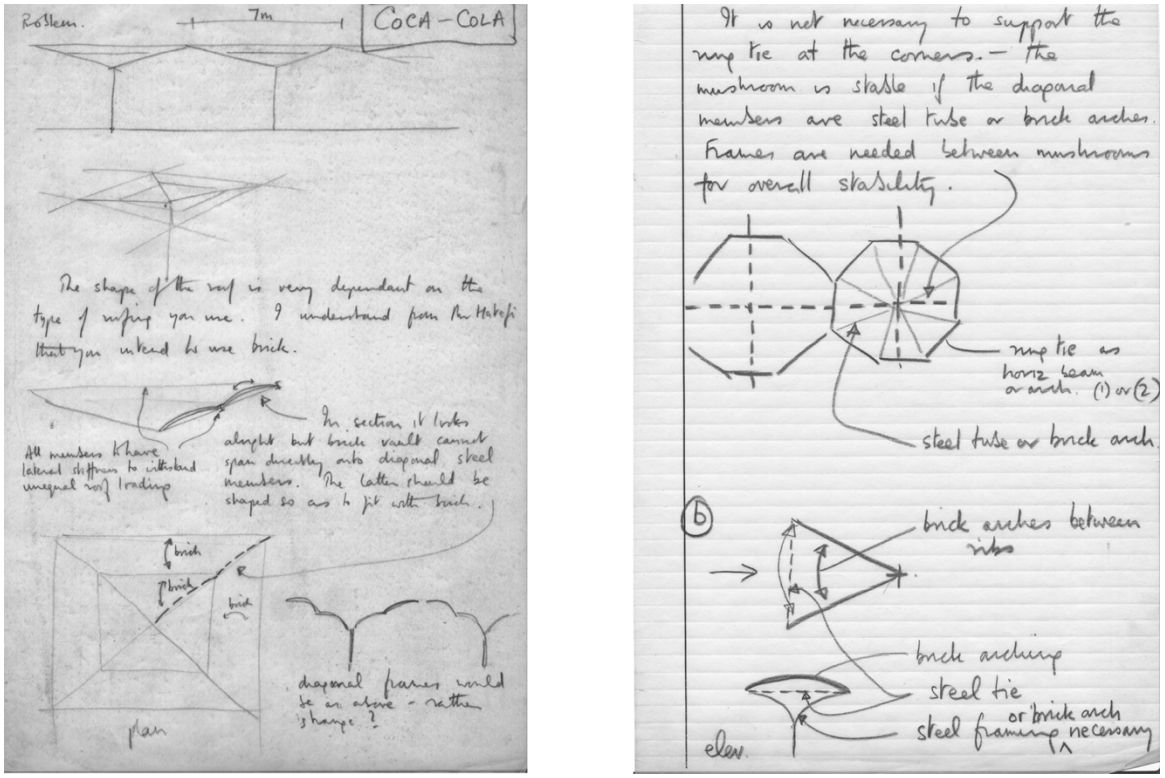

Figure 3: Pages from Newby's letters to Spero Daltas dealing with the design of the Coca-Cola plant and garden building for Princess Fatima

While this correspondence presents a fuller account of collaboration than a simple collection of sketches there are many examples of Newby's approach in sketches that he kept relating to many other jobs. In these we can sometimes see work from the very earliest sketches, which present a picture of the engineer exploring the structural possibilities that would then be presented to and discussed with the architect. For the Luton Airport hangar, for example, he first considered hangars at other airports and then sketched a range of options. For the dining hall at Marlborough College he presented the architect with a number of possibilities from which the architect opted for a reinforced concrete folded plate roof (Fig. 4). A scheme using that was presented to the college but in the event construction considerations must have prevented that from being adopted and the roof as built is a timber structure.

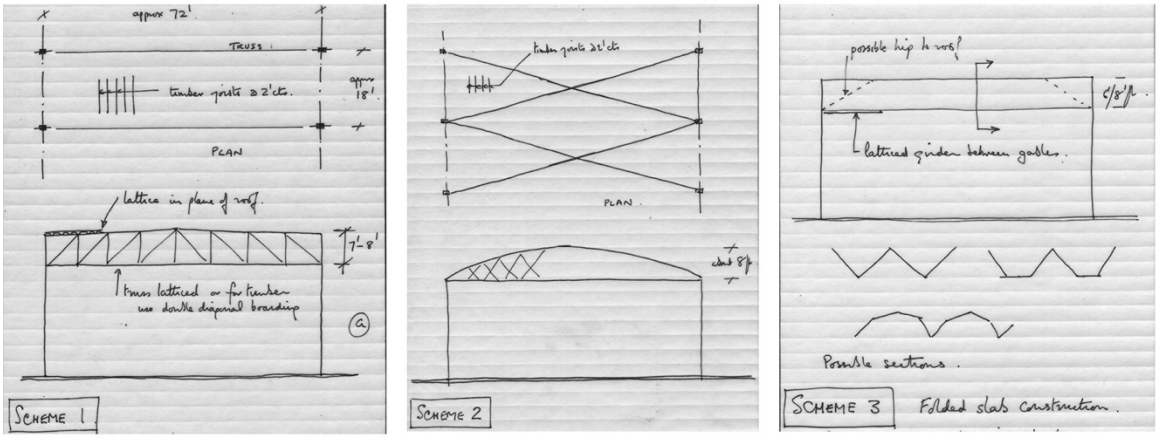

Figure 4: Three contrasting schemes for Marlborough College dining hall

Newby's papers show that an exploration of alternatives was a consistent feature throughout his design process, even when the overall form of the building was decided. He would, for example, consider alternative spanning arrangements for floors and roofs to determine the most advantageous layout. He seems to have considered the exploration of alternatives to be an essential part of the service that he provided for his clients.

The difficulty is that there are few accounts of such collaborative exchanges provided by architects. Bill Howell gave an unusual account of a design carried out with Newby, publishing the sketches that they produced between them [30]. Unfortunately the original sketches have not survived and it is difficult to tell who did which of them so that the sequence, and hence the progress of the design, cannot be followed. In this particular case Howell was after a clear expression of the structure so that it was only natural that he wanted to work closely with his engineer and also be prepared to acknowledge the latter's contribution.

While it is possible to recognize structural ingenuity in completed projects it is not possible to see whether such structural ingenuity has been required by the nature of the architect's design or because the engineer has suggested forms that the architect was unaware of. Only occasionally does this become apparent. There were two clear examples of this in Frank Newby's collaboration with Stirling and Gowan for the design of the engineering laboratory at Leicester University. The architects originally assumed that the large projecting lecture theatre would need to be supported by a pair of columns but Newby demonstrated that it could be cantilevered (Fig. 5). Also the top floor laboratory had columns in the access road that was objected to by the client [31]. There, Newby showed that the columns could slope back to the main structure. Sloping columns were again used to enable the step-back in the floors of the Cambridge history library and to form the main structure of the Florey Building at Oxford. Newby subsequently commented on how Stirling learnt to use this technique [32].

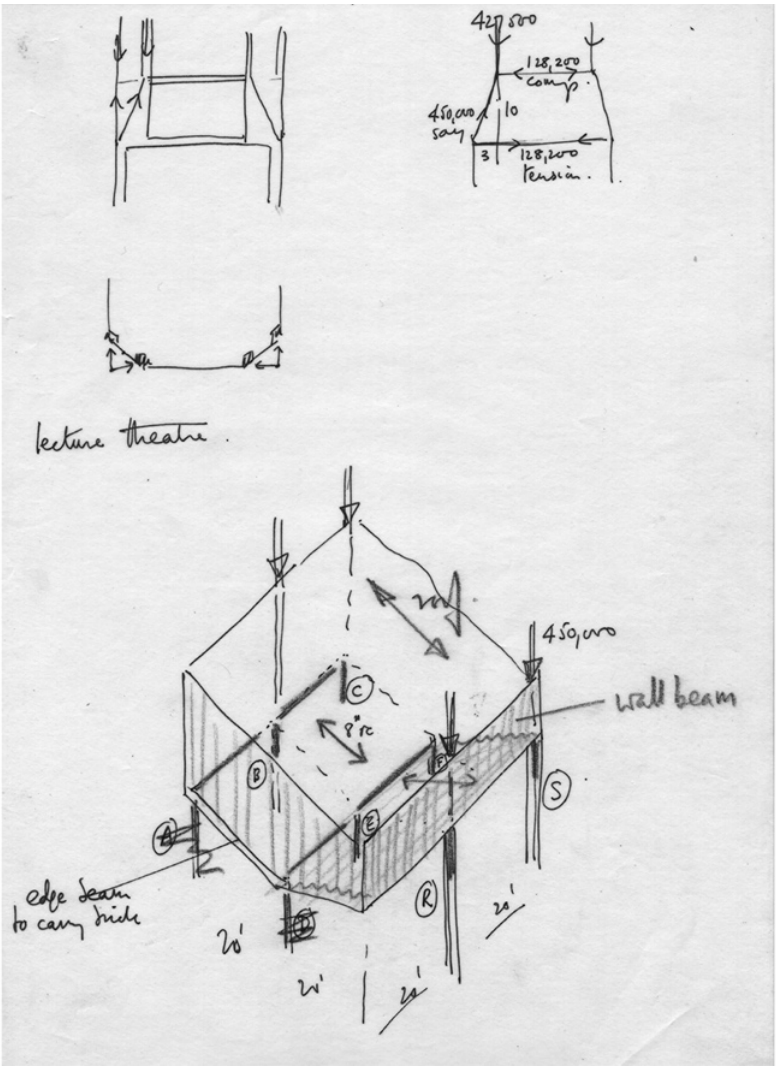

Figure 5: Newby's working sketch for the Leicester Engineering Laboratory lecture hall

Although Anthony Hunt has published a book of his Sketches, illustrating a range of possible structures for different projects, these were hardy produced as part of the conversation with architects [33]. They are just too neat and hardly reflect his description of designing the Don Valley Stadium:

> 'Flood the project with ideas bounced back and forth between the designers and the result will be a concept. Often it is unclear as to who actually designed what because the iterative proves developed between the whole team [34].'

Or for work with Foster Associates:

> ' . . .a process in which everyone draws and scribbles away, people make suggestions, others take them up and develop them . . . Gradually the design evolves [35]'

Theses romantic accounts of the collaborative design process cannot apply to all situations, perhaps only for work on competitions. Of his more usual collaborations we know little and it is a pity that his *Sketchbook* does not have some commentary on the process and the choices made.

The process

For there to be effective collaboration between architect and engineer the latter should ideally be engaged at an early stage as advocated by Oscar Faber. However he said nothing about the nature of the relationship.

Engineers rarely write about the design process still less about the process of collaboration but a unique example of an engineer commenting on his collaboration with a particular architect is that by Komendant on his work with Louis Kahn [36]. While his account suggests that Kahn respected his ability to comment on architecture it also suggests that Kahn was unwilling to concede his engineer's ability to be creative. What does seem clear is a rather impractical approach by Kahn when it came to construction, which produced problems at the Kimbell Art Museum. Andrew Saint has drawn attention to the very different recollections that Kahn and Komendant have of the resolution of these problems [37]. But the explanation lies in Komendant's explanation for such divergent views as Kahn's reluctance to credit his associates, something he thought common to almost all architects, a view that Saint also quotes [38].

Experimental work has shown that even when reputations are not at stake designers do not necessarily have good recall about the design process [39]. The experiment simply concerned architects and perhaps recall is poorer when it comes to the contribution of others. Whether or not there is close collaboration between architects and engineers allowing the latter to do more than just the dirty work depends upon the personalities of both. There are clearly architects willing to engage with their engineers while others would prefer to keep them at arms-length until the design is developed. Equally there will be engineers who are happy doing just the dirty work, possibly unwilling to advise on possible options available, perhaps because engineers receive little or no training in design.

Conclusions

We might reasonably ask whether there is any common pattern connecting those engineers who can be identified as working closely with architects. Newby and Hunt both came from the Samuely stable although Newby had a greater contact with architects as a young man throught living at Lawn Road Flats, which was a Mecca for architects. In 1951 he would have met the former members of the Bauhaus returning to London for the Festival of Britain.

Samuely had worked for contractors in Vienna and Berlin before setting up as a consulting engineer. We know of collaborations with Eric Medelsohn and Arthur Korn for whom he designed steel frames. Ove Arup, working for Christiani and Nielsen appears to have had no working contact with architecture until he himself designed the Labworth Café and then worked with Lubetkin and Tecton on buildings for various zoos. He made the important contribution to the Highpoint I flats based on his experience with the structure of concrete silos. His move to J.L. Kier & Co. was to enable him to work more on architectural projects and his later work with Lubetkin and Tecton has been discussed elsewhere [40]. In contrast to Samuely who worked with all structural materials, welded steel, reinforced concrete and timber, Arup remained essentially a reinforced and prestressed concrete engineer.

Oscar Faber initially made his name with research into the strength of reinforced concrete beams. His contemporary, Owen Williams, after graduating as an engineer worked briefly for the Indented Bar and Concrete Engineering Company before going to The Trussed Concrete Steel Company, both contractors with patented reinforcing systems. His career was then largely in bridge engineering with a few but prominent buildings to his name as an architect.

If we compare these different careers the only one with close contact with architects seems to have been Frank Newby. The principal common factor seems to be simply that all of them took an interest in architecture. It is also Newby's personal papers that provide the best insight into working practices when there is collaboration between an engineer and his architect clients. They provide a far from a complete record of the various jobs but they do provide a picture that we are unlikely to find anywhere else.

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