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The work and influence of Felix Samuely in Britain

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Development of structural forms as a means of architectural expression in Britain was encouraged firstly by engineers who worked for architects of the Modern Movement in the inter-war period and then by the need for innovative structural design to deal with the shortages in the period of post-war reconstruction. One of the key figures in this development was Felix Samuely who came to Britain in 1933 and was highly influential. This influence was partly because he was one of the more innovative engineers of this day and partly because his work was well reported in the architectural journals. In the inter-war period his work included a number of notable buildings including Simpson's Store, Piccadilly, London and the De la Warr Pavilion, Bexhill, whose forms let to the design of innovative steel frame structures. In the post war period of reconstruction his work was determined by the urgent needs of the country for factories and schools but constrained by the shortage of building materials. In this climate Samuely was to make considerable use of such devices as star beams, prestressed concrete and folded plates in both steel and concrete.

While the influence of other engineers on the architecture of the inter-war period has been chronicled Samuely's influence has received less attention. This study, based upon the archives of his firm considers the scope of his structural invention and the extent of its reporting in contemporary journals. It will provide a survey of his work to show the range of his structural designs and a commentary on the extent to which these were covered by the architectural end engineering journals to provide some measure of his potential influence on architects and other engineers of the time.

The work and influence of Felix Samuely in Britain

The organization of design and construction in Britain involving the employment of consulting engineers does not result in the emergence of figures like Nervi or Perret. As contractors these men developed construction techniques that they used for a number of their projects so contributing o their overall architecture. It also means that their names have become associated with prominent buildings in a way that is unusual for engineers in Britain. In Britain the architect retains the lead role the variety of projects handled by consulting engineers means that rather than figures emerging because of their contribution to, or the development of a construction method, engineers have been successful through their ingenious use of available methods, their opportunity to use these dependent upon their ability to work with the architects who engaged them. This is the kind of contribution made by Felix Samuely whose work in Britain spanned the immediate pre-war and immediate post-war years.

Samuely left his practice in Germany and after first working briefly in Russia he came to Britain in 1933 where he decided to settle. In May of that year the Borough Council of Bexhill had given approval for the construction of an entertainment pavilion the design competition for which was won by his fellow émigré Eric Mendelsohn who then employed him as consulting engineer for the structure. Thus his career in Britain was immediately launched. The significance of this building was that it was both a major Modern Movement building in a country that had been rather slow to adopt these new continental ideas and the first major architectural project to use welded steel. Samuely then attracted a number of other clients from the Modern Movement in Britain much of this work involving the houses and apartments that they designed. His contribution to the architecture of the period is apparent just from a list of the architects and their projects that he was involved with. In construction terms t is for his contribution to the early development for welded steel in buildings that he is best remembered but he also showed some ingenuity in the pre-war use of reinforced concrete.

Immediately after the war, with his reputation established, he contributed to the schools building programme, a major undertaking in post-war Britain (Saint 1987). The scale of Felix Samuely's involvement in this may be gauged by the 37 schools and 6 college buildings that he was involved with in the years between 1945 and 1952. In the work on these he developed the use of precast concrete and folded plate construction, sometimes combining them, and showed considerable engineering flair in other ways, often needed at that time to overcome shortages of construction materials. His involvement with the Festival of Britain and the design for the Skylon, an engineering tour de force, was a far more visible manifestation of his talents, and there were other major projects in which he used prestressed concrete, another innovative form at the time. Nevertheless it is the less-visible engineering of his schools projects that is more important in the context of this conference. He was also keen to publicise the work that he did. This may have been with the intention of attracting more work but is more likely associated with his interest in teaching. In either case, its effect would also have been to bring the structures that he used to the attention of others and so help widen the use of these techniques.

Welded steel

The development of steel structures in Britain had been hindered by the rather restrictive building regulations. In fact there were problems with the introduction of any novel form of construction because of the prescriptive form that these regulations took, enshrined either in the Model By–laws or in the London County Council (LCC) Building Acts. Regulations for steel construction had been produced for the latter in 1909, before welding for building had been contemplated and by the late 1920s the situation for bolted or riveted structures was also far from satisfactory. A Steel Structures Research Committee had been set up to look at the rather irrational methods of design being employed and a Welding Panel of this committee was formed in 1930 but, as was pointed out at the time (Caldwell 1930, 104–5), the development of welding as a practical method of building construction was still hindered by the LCC Act. Other local authorities, without the resources to develop their own regulations, tended to rely upon the London rules for both steel and reinforced concrete frames. Nevertheless it would be misleading to suggest that there were no welded steel frames put up at that time nor that there were not those who were experimenting with the use of welded construction in large scale buildings (see for example McBride 1935). It seems to have been easier to use this and other new forms of construction outside London where local building inspectors could be persuaded to relax the regulations.

Of course it was most often for factory structures that welded construction was used. The journal *Architecture and Building* (1932) had reported an all welded factory for The Matrix Welding in 1932 and the following year the Bata shoe company put up a factory in England, the technology for which was simply imported from its native Czechoslovakia (*Architecture and Building* 1933). Helsby, the engineer with whom Samuely went into partnership, had also designed welded steel structures and published articles on these (Helsby, 1932 & 1934) and it may well be this mutual interest that attracted Samuely to joining him. The significance of Samuely's contributions to this development was the prominence of the buildings that he worked on, the comprehensive use of welding within the structure and the novel forms of construction thus introduced.

De La War Pavilion and Simpson's Store

R. B. White (1966) claims that Mendelsohn and Chermayeff's original idea was to have a reinforced concrete structure with the intention of being able to have continuous soffits, unbroken by projecting beams but that steel was chosen when this proved impossible. The possibility is that they had gone to Kiers for the structure, which is where Samuely worked on first coming to Britain, and it was the opportunity to design a steel structure that was the stimulus for his going into partnership with Helsby and Hamman. Mendelsohn would surely have known Samuely as having worked on the first all-welded steel-framed building in Berlin. But the pavilion required a little more than a basic welded frame. There were a number of areas where some ingenuity was required to meet the requirements of the architecture. Of course, much of the ingenuity in the structural design was completely invisible and only apparent by looking at the structure in detail.

The central section of the plan in the area of the conference room was to be kept free of columns on the first floor and because of this the second floor was suspended from plate girders in the roof. The hangars for this comprised 1/2» plate, which could be housed within the thickness of the partitions and which went through the flanges of the plate girders and was welded to their webs. Hangars were also used in the external wall because of the continuous run of doors and windows on the ground floor. The lintols over these were suspended at intervals from the plate girders above. But the large areas of wall above these openings also presented problems for carrying wind loads back to the columns. The solution here was to use pairs of channel sections with plates welded between to form Vierendeel girders, another welded structure. All of this was hidden within the construction of the external wall.

Where the advantage of a welded structure was more apparent was in the handling of the staircase, which was an important feature of the architecture. Mendelsohn had made a feature of the staircase in his Schocken Department Store in Stuttgart where it had projected from the front of the building at the corner. At Bexhill he used a similar device at the centre of the building to divide the auditorium area from the restaurant but made this more dramatic by not only enclosing it within a glazed curtain wall but also by carrying cantilevered balconies round the outside of this curtain wall in a semicircle (Fig. 1). Only two columns were used to support the balconies and in order to carry the torsion moments their curved beams had to have a very heavy web section to limit their thickness while the columns were built up as strong box sections to carry the bending moments. Welding also helped with the long spans of the auditorium roof that had trusses at nearly 12 m (38′6″) cts with the shallow pitched roof trusses spanning nearly 23 m (74′10″). Secondary girders 1,5 m deep spanned between these. Shortly afterwards Samuely was also to use welded steel trusses for the roof of film studios at Shepperton (*Architects' Journal* 1936a).

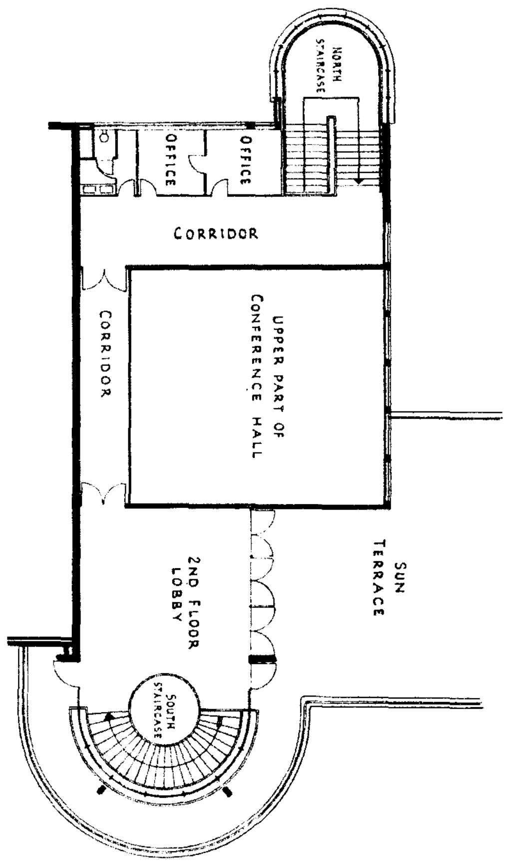

Figure 1
De la Warr Pavilion, Bexhill. Upper floor plan of the central section showing the way in which the sun terrace is carried round the outside of the main stair

Immediately following its construction Samuely published a series of articles in *The Welder* (Samuely 1935) but this series was not likely to be read by architects, and possibly not even by the majority of structural engineers. Therefore it was its coverage by the architectural journals that would have drawn the attention of architects to the possibilities of welding. The building was indeed well reported in these journals both for its architecture and its structural novelty. However it was Samuely's next major essay in welded steel that was to attract more attention for this aspect of its construction largely because part of the original structural design was not put into effect.

The publicity surrounding the design of Simpson's Store, in Piccadilly, London was significant partly because it so clearly demonstrated the restrictive effect of the LCC building controls. The original intention was for columns on the front elevation supporting upper floors to be brought down to a deep welded structure that spanned across the first and second floors but objections from the LCC required the loads to be carried by beams at each floor. That the resulting structure had a much greater weight of steelwork ad so was far less satisfactory was made clear in a detailed study by the *Architects Journal* (1936b) (Fig. 2). It is also clear from the drawings for this article, and from progress photographs, that the large welded structure had already been fabricated before the decision against it was finally made. The top and bottom chords of the first and second floor frame were simply placed in the building without the end pieces that would have connected them together and transferred the bending moments. Above this the plate girders to carry the other floors were conventionally riveted because the steel fabricators did not have the capacity to weld these; presumably they could not be produced in time. In spite of the difficulties with the frame at the front of the building welded steel was used elsewhere in the construction and many of the welding details, including those of the staircase were illustrated by the *Architects Journal* (Fig. 3).

By this time the situation for welding appeared to be improving as the LCC regulations were changed in 1935 following which Helsby and Samuely (1935) published an article that discussed these regulations in some detail. Samuely also designed other buildings using welded steel including Whittinghame College, Brighton that was partly welded steel and partly

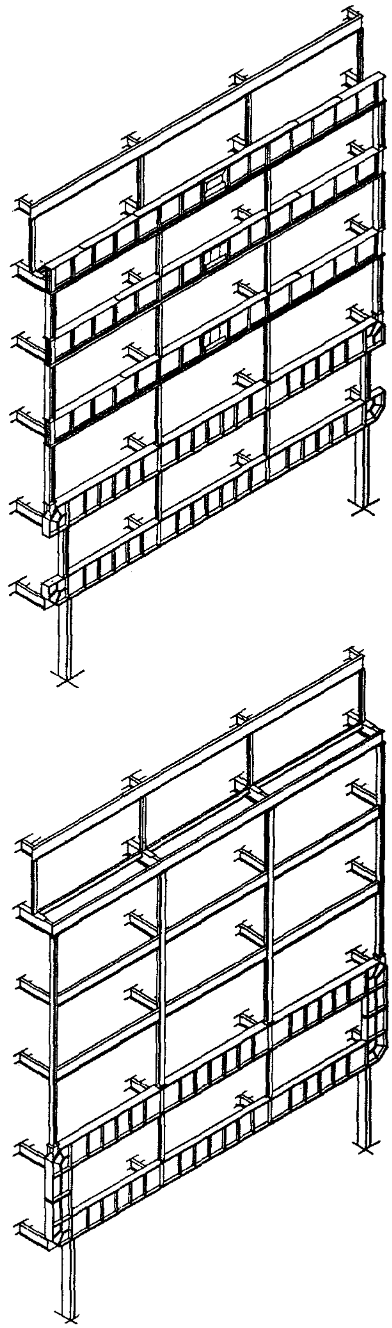

Figure 2
Simpson's Store, Piccadilly, London. Analysis of the frame as designed and as built. From *Architects Journal*

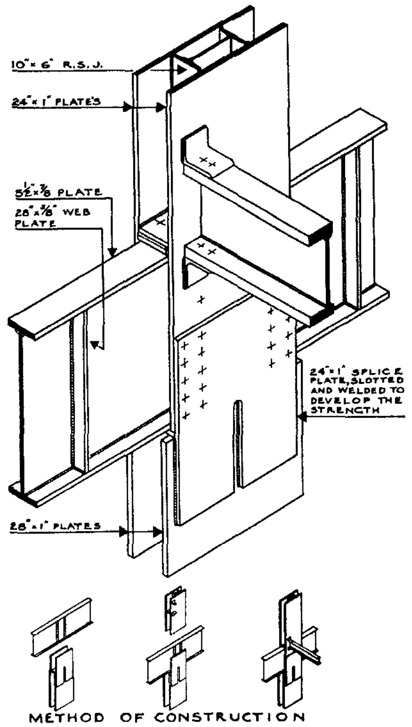

Figure 3
Simpson's Store, Piccadilly, London. Details of the welded frame. From *Architects Journal*

reinforced concrete, and described in considerable detail in the *Architects Journal* (1936c). Although largely a reinforced concrete frame building (see below) part of it had a steel frame with stanchions formed of angles welded together. The roof trusses over the assembly hall had T section chords with 1″ diameter rod bent to form the internal members —a precursor to the light trusses that were developed as standard building products and used extensively after the war. (Fig. 4) Whittinghame College also used a form of concrete construction that presaged a past-war system because Lewis dovetail sheeting was used as both permanent shutter and reinforcement for the concrete topping (Fig. 5).

REINFORCED CONCRETE

Samuely's possible contribution to the development of reinforced concrete design is less clear. In his first few months in Britain he worked with Ove Arup at Kiers and both were to use a form of structure that broke from what was the norm until then. Reinforced concrete had been used almost as a substitute for steel —simply as a series of repeated frames on a regular grid. The only alternative had been the use of flat-slab construction, introduced into Britain through links

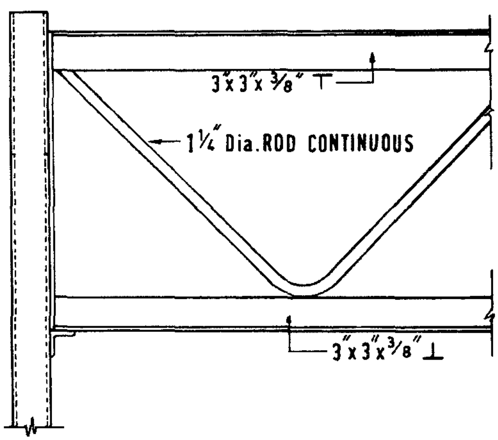

Figure 4
Whittinghame College, Brighton. Detail of the welded roof truss over the hall

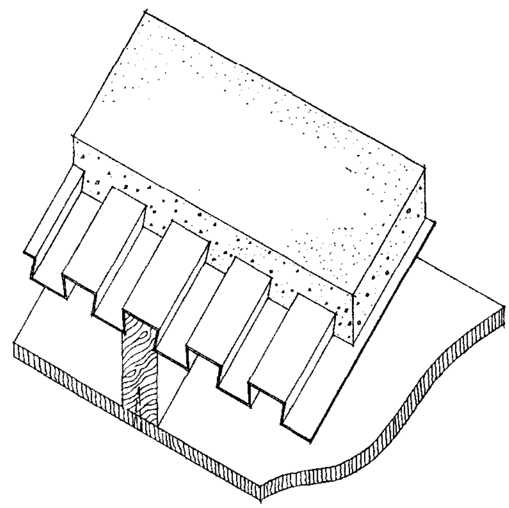

Figure 5
Whittinghame College, Brighton. Detail of concrete roof construction.

with the United States, another form of construction that had run foul of the LCC regulations (Yeomans. 1997). The way in which both Arup and Samuely used reinforced concrete was to treat the external wall frames as primary structural elements with the floor slab spanning across the building to a spine beam (rather like medieval timber-frame construction). Apart from eliminating the regular frames of columns and beams across the building, this arrangement allowed greater flexibility in the placing of columns because there was no necessity for those supporting the spine beam to respond to those on the external walls, nor even for them to be equal distances apart; they could be wherever was convenient for the plan. Arup used this arrangement in his Highpoint One design for Tecton and for their winning entry for the Cement Marketing Company's Working Class Flats competition (Yeomans and Cottam 1997).

Samuely used this structural layout for Gilbey's offices in Camden Town, London. These offices were sealed against the street noise and so required air handling ducts and these ducts were incorporated into the structural spine of the building. He used it for the concrete framed part of Whittinghame College for Pilichowski (Fig. 6) (already referred to above). (He also used this structural layout for a house in Chelsea for Mendelsohn and Chermayeff (Myerscough-Walker 1937; Yorke 1937, 32–33) although the latter was a brick building with the spine beam of steel.) But most noticeable at the time was its used for a small block of flats in Golders Green by Pilichowski, whose structure was described in some detail by *Architectural Review* (1935), likening it to the skeleton of a fish. No engineer was credited with this design but as the construction was by Kiers (*Builder*, 1936) one might assume that the design was by Arup. However, that Pilichowski subsequently chose to go to Samuely for the structure of Whittinghame College suggests that his flats might also have been designed by Samuely in the period during which he worked for Kiers. Given Samuely's subsequent track record in getting his buildings described in the journals it would not be surprising if he were to prove to be the author of both building and structural explanation.

Samuely's real demonstration of the possibilities of reinforced concrete for new structural forms came with his collaboration with Wells Coates for the Palace Gate Flats, London. He had already worked with this architect for some flats in Hove but these were fairly conventional in their structure. The Palace Gate flats were far from conventional in either plan or structure. Coates had been experimenting with three-dimensional planning in his own studio apartment and was now to apply a similar idea on a much larger scale to a complete block of flats. The three-dimensional way in which the accommodation was arranged would simply not have been possible with a conventional structural frame. To accommodate the complex planning Samuely had to design walls to act as beams and to hide other beams within the depth of the floor slab. This was another well-publicised building with an extensive coverage in *Architectural Review* (1939). But although it was a clear demonstration of the kind of freedom in planning that was possible to architects through the imaginative use of reinforced concrete it could not have had any

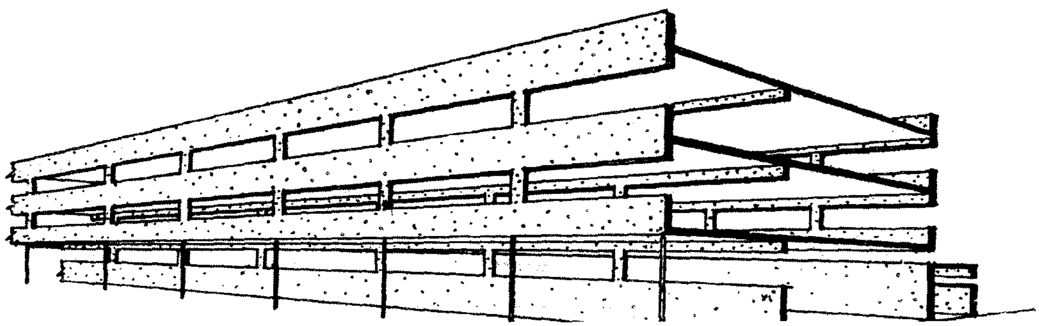

Figure 6
Whittinghame College, Brighton. General layout of the reinforced concrete structure

immediate influence on the architects of that generation because of the onset of the Second World War

Post war reconstruction

In the post-war period Britain required a massive building programme, partly to make up for the destruction caused by the war but partly because of there had been no building during the war other than for war purposes. Schools and housing were now the principal and urgent requirements. The difficulty facing the country was that the need for these buildings came at a time when there was a severe shortage of building materials and a massive foreign debt. Timber was a particular problem because Russian supplies were no longer available and Britain did not have sufficient foreign exchange to buy from North America. But there was also a shortage of steel that encouraged the use of reinforced and prestressed concrete rather than steel-frame construction. In this climate engineers looked for structural solutions that would economise on the use of materials. Not only was there a tendency to produce rather «tight» designs but there was also an advantage in finding structural forms that would be more efficient and methods of construction that would economise on materials. While concrete was preferred because of the saving of steel, precast concrete was preferred to insitu-concrete because it could reduce the amount of formwork needed and prestressed concrete was preferred to simple reinforced concrete again because of the saving in steel. Moreover, in the immediate post war years it was not simply price considerations that affected the choice of scarce materials but the requirement for building licences that allowed the authorities to control those that were used. In this climate Samuely developed techniques that economised on the use of materials and that were to form part of the repertoire of techniques more widely used in the post-war years.

Precast concrete

Precast concrete had the advantage that it saved on the timber required for shuttering. An example of this was a laboratory for Fina Petroleum at Orsett for which precast concrete was reportedly used because the authorities would not release plywood for the shuttering necessary for in-situ concrete (*Architect and Building News* 1952). Both frames and floor structures could be precast, the engineering issue for the former being to make connections between the frames. Many of the structures that Samuely devised used precast concrete wall frames, as in the laboratory building referred to above although Hatfield College used dramatic two storey high transverse frames. As such this was reported in some detail in the *Architectural Review* (1953) while the less dramatic wall-frame structures received less attention. This and a number of Samuely's other structural innovations were used in Thomas Linacre School, Wigan that was widely reported in the journals (e.g. *Architecture and Building*, 1953: *Builder* 1954) although not well illustrated.

The main teaching blocks used precast concrete frames to form the external walls with the floors spanning 6,9 m across the building between them. These precast frames here were fairly simple comprising pairs of columns at approximately 1m centres with head and sill members cantilevered half a bay beyond them. Bolts and steel plate connectors were used for the precast units so that as much as possible of the construction was dry. This was to save formwork and such a composite of precast and insitu concrete was to become part of the firm's stock in trade. It was reported that the floors were cast as erection of the frame proceeded from one end to the other.

The journals that reported this building did not include drawings of the construction and for this we have to look at other buildings of the time. A larger scale version of this wall-frame arrangement that was to become an important type of construction was later used on a larger scale by Samuely for Fielden House, an office block in London that was described in detail by *Architecture and Building* (1954a & b). By now the idea had been developed with short sill and lintol pieces to connect adjacent frames and with the floor structure formed with secondary beams and Samuely's system of precast troughs to form a permanent shuttering composite with the insitu topping above (Fig. 7). The illustration shows another Samuely device that he used widely. His floor structures often comprised a series of thin precast concrete troughs over which there was an in-situ

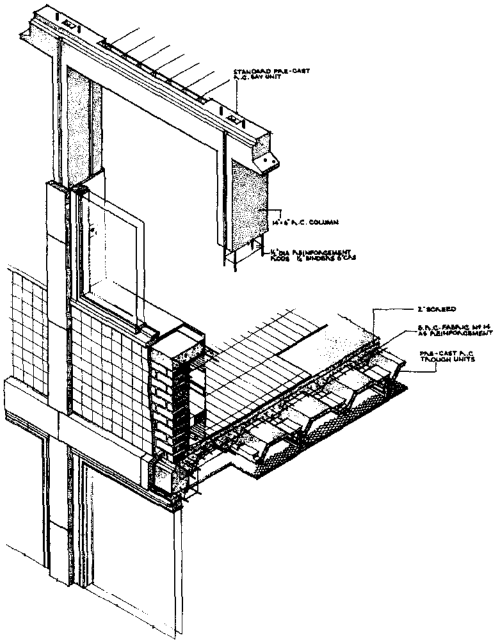

Figure 7
Fielden House, London. Precast concrete wall frame and composite precast and in-situ concrete floors.

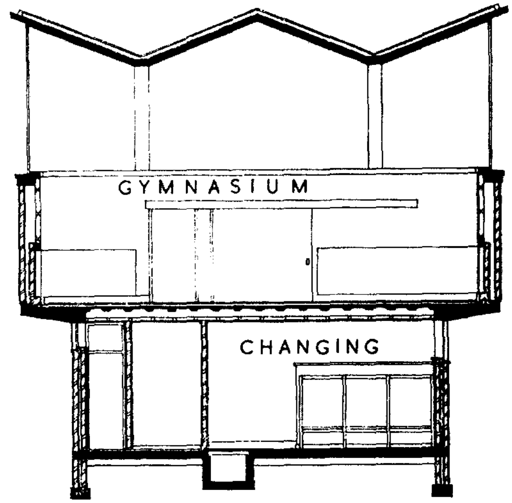

Figure 8
Woodberry Down School, London. Section through the gymnasium showing the folded plate roof

topping to produce a composite precast and insitu structure.

Folded plates

One of the effects of the post war shortages seems to have been to encourage the development of shell roofs for factory building. Before the war Samuely had designed a shell roof for Folkestone Rotunda and published the calculation method used for this (Samuely 1938). However, the advantage with folded plates was that the flat elements of which they were composed could be precast so that little insitu formwork was required. In schools, assembly halls and gymnasia had large spans that provided the opportunity for the use of folded plates. The most dramatic of these was for the gymnasia buildings for Woodberry Down School, London where the folded plates are arranged like bird's wings to provide clerestory lighting. (Fig. 8) But this was unusual and we might suppose used for architectural effects as much as for economy. His other roofs are far more conventional. At Thomas Linacre School he constructed the roof of the hall using a folded plate formed of precast concrete elements with an insitu topping.

The overall form comprised four planes of concrete that here spanned 14.5 m across the hall and nearly 23 m between end supports but with an additional 4.6 m cantilever at he stage end. One advantage claimed for this form was that the windows could be carried to the soffit of the roof. But this architectural advantage seems nothing to the constructional advantage of the method. Instead of requiring formwork to support the concrete each plane of the roof was first formed of precast concrete trough elements 2,5 cm thick but about 10 cm in overall depth. These could simply be supported on three lines of scaffolding down the length of the hall while insitu concrete was cast over them. Although (as noted above) this building was reported in a number of journals none provided any technical details of the construction and for this we have to look at Kingsmead School, London that was of smaller span

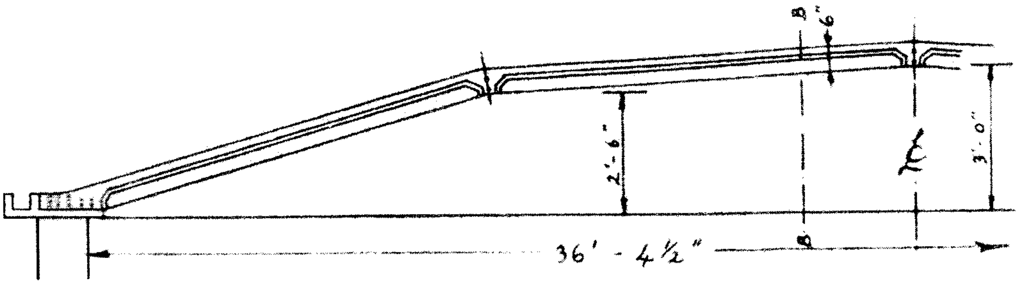

Figure 9
Kingsmead School, London. Details of the folded plate roof over the hall

but formed in the same way (Fig. 9). The *Architects Journal* (1953) reported on the construction of this school noting that the insitu concrete was a 5 cm screed with transverse top steel to take local bending moments. It also noted that the main steel «has been bent up in the plane of the roof along the lines of principal stresses» and that «ridges were cambered to counteract the expected deflections.» In the event the deflections were less than expected. Although it would be foolish to claim that it was entirely the result of an economic roof structure Kingsmead School was particularly cheap. The Ministry of Education imposed a limit of £170/place on the costs of schools in its building programme; the article noted that Kingsmead was built for £154/place.

Prestressed steel

Of course folded plates could equally well be constructed of steel and Samuely produced a number of these. The roof of the workshops at Thomas Linacre school had what was reportedly the first example of prestressed steel in Britain (Prefabrication 1956). Samuely had been involved in an essay in prestressed steel two years before when he designed what was presumably intended to be a standard roof design for Sommerfelds, a firm of steel fabricators (Architects Journal 1954). This roof consisted of pyramids of sheet metal carried within frames made of angles but with tubes between their apexes to form the top chord. This was prestressed with cables within the steel tubes and was to be erected on the ground and lifted into position. But although a prototype was built it may not even have been marketed.

The workshop of the school was quite different except that it too was assembled on the ground and craned into position. From the outside all that one sees is a pair of simple hip-ended roofs, the plan of which is seen in figure 10. However they are essentially folded plate structures spanning in the long direction and thus providing an interior space without columns. Sections of each slope were first welded up and then assembled to form a complete roof section that was lifted into place. The prestressing cables within this that take the form of a bending moment diagram in the slope of the roof

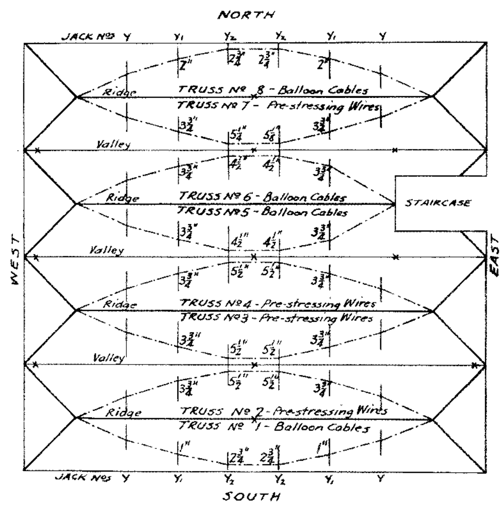

Figure 10
Thomas Linacre School, Wigan. Plan of prestressed steel roof over the workshops

were then fixed into position. Figure 10 is taken form a drawing made at the time to record the prestressing process and the amount of lift generated as it was applied. Lines marked «y» are the rafter positions, there being no diagonals within the roof. It shows that a combination of purpose-made prestressing cables and barrage balloon cables were used for the prestressing. At a time when there was a shortage of steel the now surplus balloon cables were used as prestressing cables in a number of building structures.

Publications

That Samuely's buildings were extensively reported in the journals of the time may be partly attributed to his work with Modern Movement architects. The journals naturally had an interest in this development and the significance of the structural engineering contribution. At the same time Samuely was interested in publishing himself, an interest that he seemed to share with Haman, one of his pre-war partners. A comprehensive study of Samuely's publications would occupy a paper in itself and only a brief summary is possible here. At first his publications considered technical issues of design and construction. As well as the series of articles on the structure of the Bexhill Pavilion he wrote another on the use of welding for Vierendeel s in roofs (Samuely 1937). But he was as interested in communicating with architects as with fellow engineers. Just before the war he produced a book on building construction in collaboration with his partner Hamann (Samuely and Hamann 1939a) and while a second volume was written the coming of the war prevented its publication: instead they produced a book on the design of air raid shelters (Samuely and Hamann 1939b). After the war he wrote for architectural publications, dealing in particular with space frames and stressed skin structures; structures that derived their properties from their geometrical forms (Samuely 1949, 1952a & b). This proselytising, if it can be called that, even extended across the Atlantic when he gave short on space frames (Samuely 1953) that was a keynote address in a discussion between a number of eminent architects and engineers that was reported in *Architectural Forum*. Samuely also provided the structure of a church in Connecticut for Wallace Harrison that used precast folded plates (for details see Wagner 1998).

The post-war period was one where architects had become aware of the architectural possibilities of modern structures and Samuely was interested in contributing to this development, publishing far more than would normally be expected of a consulting engineer. Meanwhile the buildings on which he worked continued to attract the attention of the architectural press. Elsewhere I have suggested that the need for economical designs in the immediate post-war shortages was a contributing factor to the development of a climate in which consulting engineers were rather more routinely engaged instead of leaving the structural design to be carried out by the contractor's engineer (Yeomans 2000). However another factor was emergence of consulting engineers who were both able to take an active role in the design process and also to design structures that went beyond simple frames. Samuely was not only a leading figure among such engineers but was the most active in developing methods of construction that could be applied widely. This has only been a sample of the work that he did and the structural devices that he used. A full appraisal of his work has yet to be carried out.

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