Chapter 2. Ove Arup: Theoretical and moral positions in practice and the origins of an engineering firm

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Abstract

Founded by Sir Ove Arup in 1946, Arup is one of the largest global engineering consultancies offering design services for the built environment. Throughout his career Sir Ove continually reflected on his practice and its role in producing more or less socially robust urban environments. Analysis of documents from his personal and professional archive provides a case study of a practice-based engineer-philosopher. Sir Ove's writings and reflections develop the central elements of his 'Total Design' philosophy: a philosophy that can be characterized as an engineering philosophy of technology as defined by Carl Mitcham (1994), based on an instrumentalist understanding of the nature of technology (Feenberg 1993). Through this case study we see how an influential engineer addressed issues of engineering method, the purpose of engineering, and its role in society, and also developed a framework for the translation of values into practice in engineering.

1. Introduction

Most engineering design for the built environment takes place in large firms, positioned between architects, urban designers and planners who conceptualize buildings and spaces, and construction contractors who build them. Engineering design mediates between creative, scientific, technical, political and practical interests in shaping the built environment. Engineers’ own conceptualizations of this role have important implications for understanding economic, social and environmental change in modern societies.

Sir Ove Arup is an important figure in 20th century British engineering, best known as the founder of the firm which now bears his name. Arup is a global consultancy whose core business is providing engineering design services for buildings, infrastructure and urban development. Throughout his career and his leadership of the firm, Sir Ove recorded his reflections on the role of engineering in society and how to achieve good design in practice. His thoughts were shaped by his experience as an engineer working within the industrial and artistic networks that constituted the built environment of post-war Britain, and were underpinned by his early education in philosophy.

Sir Ove dealt with many conventional engineering considerations for achieving quality design. He was strongly influenced by modernist viewpoints and an instrumentalist conception of science and technology, and maintained a strong interest in incorporating art and aesthetics into structural and urban design. His leadership of the firm focused on the integration of knowledge (both technical and conceptual) across the boundaries within the construction industry. Towards the end of his career he was compelled to articulate his ideas to the growing firm which was structured according to his understanding of the aims and means of good design.

This chapter maps the issues of concern to Sir Ove, a practice-based engineering-philosopher. The case study is intended to illustrate some of the moral, theoretical, organisational and personal concerns of engineers. We characterise Sir Ove's reflections as an example of what Carl Mitcham (1994) has defined as the "engineering philosophy of technology – or analyses of technology from within, and oriented towards, an understanding of the technological way of being-in-the-world as paradigmatic for other kinds of thought and action" (p. 39). We show that Sir Ove's analysis of technology conforms to the instrumentalist view, which Andrew Feenberg (2002) identifies as consistent with dominant policy and engineering approaches. Sir Ove's instrumentalist view of technology does not correspond to an instrumentalist view of engineering. The Arup case also shows how large, modern-day engineering consultancies are underpinned by specific theoretical and moral perspectives.

This chapter begins with an introduction of the core analytical concepts derived from Mitcham (1994) and Feenberg (2002) – engineering philosophy of technology and instrumentalist theory of technology respectively. We then provide a brief biography of Ove Arup before analyzing his speeches and writing in terms of his thoughts on technology and morality, the structure of the building industry, his theory of Total Design, and the 'Aims and Means' of the firm he founded. This material is based on a document archive held at the Arup's London headquarters, which includes papers, conference proceedings, speeches, lectures and addresses, interviews, notes, doodles and other memorabilia. The material analyzed spans a 41 year period of Ove Arup's career from 1942 (just before he set up his own firm) to 1983 (5 years before his death). We conclude by drawing attention to the contribution of practice based engineering-philosophy in understanding the complex relationships between values, technology and society.

2. Considering Philosophical Positions

Ove Arup's practice-based engineering philosophy is consistent with analyses of philosophies of technology by Carl Mitcham (1994) and Andrew Feenberg (2002). Whilst Sir Ove's contribution to the profession was innovative, it can also be shown to be consistent with accepted understandings of the role of technology in liberal progress, and a tradition of engineering analysis of technology from within.

Mitcham (1994) divides philosophies of technology into two broad categories; ‘Engineering Philosophy of Technology (EPT)’ and ‘Humanities Philosophy of Technology (HPT)’. EPT describes any “attempt by technologists or engineers to elaborate a technological philosophy” (p. 17). EPT is philosophy of technology from ‘within’ and is pre-conditioned towards a pro-technology stance, often proceeding first with an analysis of the nature of technology - its concepts, methods, cognitive structures etc – and then seeking to explain further aspects of human experience or affairs in these terms (Mitcham 1994). HPT represents “effort by scholars from the humanities…to take technology seriously as a theme for disciplined reflection" (p. 17) and provides a more expansive framework, tending towards more critical accounts of technology and its relation to other aspects of human experience such as art, literature, ethics and politics. Mitcham argues for the primacy of HPT on the basis that humanist aspects of engineering are usually taken for granted in EPT, which “is only one kind of questioning and can itself be questioned” (p. 140).

Feenberg’s (2002) schema distinguishes between instrumental and substantive theories of technology. Instrumental theories treat technology as “subservient to values established in other social spheres” (p. 5), and are associated with liberal faith in progress. Substantive theories claim that “what the very employment of technology does to humanity and nature is more consequential than its ostensible goals” (p. 5), and are associated with more critical perspectives, including calls for a retreat to more traditional forms of society.

Engineering theories of technology are most commonly associated with an instrumental viewpoint. Technology is conceived of as tools that engender a universal rationality which is sociopolitically indifferent (i.e. neutrally serving human ends) and hence transferable across every social context. Feenberg shows that such a view focuses discourse on the notion of ‘trade-offs’ and boundaries. The technical sphere can be limited but not transformed in character by non-technical values. Since there is a universal rationality underpinning technology, this point of view limits questions to those regarding what extent technological efficiencies should be traded off against culturally mediated considerations such environmental, ethical or religious ones (Feenberg 2002).

Positioning the reflections of Sir Ove as engineering-philosophy grounded in an instrumentalist view of technology provides a starting point for analysing his specific concerns with the organization of the construction industry and the role of values in shaping his firm.

What follows demonstrates how these broad characterizations of engineering philosophy are enacted in the specific concerns of one of the twentieth century's leading engineers.

3. Ove Arup and the firm

Born in England in 1895, Arup took his first degree in philosophy and mathematics before studying engineering, specialising in structures. As a graduate Arup developed an interest in reinforced concrete and joined a specialist contractor in this field, Christiani and Nielsen, designing and constructing structures such as quay walls, bridges, silos, water towers and coal bunkers. Despite becoming chief designer of the firm's London branch, he grew frustrated by the contractor's limited scope for developing new ideas for concrete (Arup 1969a.).

Arup became increasingly inspired by the pioneering architects of the Modern Movement such as Walter Gropius and Le Corbusier, who shared a commitment to the functional use of structural materials and an enthusiasm for engineering. Arup's willingness to explore emerging ideas meant that his collaboration as a structural engineer was welcomed. Motivated by this, Arup entered J. L. Kier & Co as a director of designs and tenders. He also joined the Architectural Association and the Modern Architectural Research (MARS) Group, a think tank for modernism in British architecture and began a long association with Tecton, the architectural partnership founded in 1932 by Berthold Lubetkin. With Tecton, he completed works such as the blocks of flats known as “Highpoint I and II” in Highgate, London, the Gorilla House and award winning Penguin Pool at London Zoo, flats for low income families, and the first examples of ‘box-frame’ construction in Britain (Jones 2006).

In 1946, again seeking increased freedom to provide engineering solutions for the Modern Movement, Arup set up ‘Ove N. Arup, Consulting Engineers’, which has been known simply as ‘Arup’ since 2000 (Arup 1969a). As an engineer, Arup is perhaps best known for his work with architect Jorn Utzon on the Sydney Opera House (detailed in Jones, 2006).

4. Technology and morality

For Arup, making the benefits available from scientific and technological advances through engineering was an inherently moral undertaking. He was vocal in emphasising the imperative of wide and participatory deliberation (to include engineers and scientists) on what the benefits of technology should be and how they should be administered. This call was based on a wholly instrumental definition of engineering as utilising technology to bring natural forces and resources to human advancement, consistent with Robert Treadgold’s early definition of Civil Engineering in nineteenth century England (Mitcham 1991). Along with new capabilities stemming from the technological revolution that allowed humans to win their "battle with nature", came a moral responsibility to properly administer the "conquered territory" (Arup 1970a p. 391).

> …this is not a technical problem at all. It is not even mainly a problem of organisation… The difficulty is rather one of getting agreement as to what benefit to humanity means ... It becomes therefore a moral or social or political problem.
>
> (Arup 1942, p. 57).

This call for scientists and technicians "as citizens with a social conscience" (Arup 1942, p. 57) to resolve the social problem of agreement on aims is in line with Feenberg's description of the manifestations of instrumental theory. Arup consistently maintains a division between the technical sphere in which a clearly articulated aim can be achieved through rational means, and social and political spheres in which inherently irrational aims must be considered:

> …to decide what to do next invariably involves value judgments, ethical and aesthetic considerations, and an understanding of human aspirations and behaviours - all of which cannot be logically deduced.
>
> (Arup 1981, p. 1)

Arup calls for scientists and engineers to engage with the arts and humanities in order to contribute to and enliven social and political debates, not to extend their analyses to bear on them. In this regard Arup refrains from an imposition of technological principles to these arenas as one might expect an Engineer-Philosopher to advocate. He does however maintain a seemingly unproblematic relation between aims as defined by such spheres and their rational realisation through engineering; he does not consider, as a substantivist might, that to realise a humanitarian aim through technological means might itself entail a further substantive shaping of either the technology itself or the social context.

5. The structure of the building industry

In establishing and practicing within his own firm, Arup situated his moral and theoretical concerns within the wider building industry of the time, focusing on three critical themes throughout his career: the architect-engineer divide; divisions between briefing, design and construction; and the limits to the specialization of knowledge.

5.1 The architect-engineer divide

Arup was closely aligned with the artistic and functional ideals of modernist architecture, and saw the longstanding division between architect and engineer as outmoded. Rather, he saw two equally valuable perspectives on any one whole design. He envisioned a balanced synthesis of the architect's concern with human reactions to form and space, and the engineer's emphasis on conquering natural forces in a rational way with the aid of science and technology.

In practice, a deep division was embodied in the industry by firms who split themselves between builders working for architects and engineering contractors working for engineers. Arup lamented esoteric practices that reinforced this divide, beginning within profesional education. An emphasis on quality and architectural theories in architectural schools neglected the important technical aspects of how to translate these values into real buildings, whilst:

> …the natural tendency of a designer to care for the appearance of what he creates was actually thwarted rather than encouraged in the education of engineers…
>
> (Arup 1970a., p. 394)

Again, Arup's instrumentalist treatment of this problem focused on trade-offs; an architectural understanding without engineering conceives of buildings and spaces without any regard for the implied trade-offs in efficiencies in structure and method of construction (Arup 1956). Conversely, optimised efficiency does not appropriately prioritise human goals of architectural delight and humane design (Arup 1972a.). Arup's 'synthesis' is best thought of as achieving the most appropriate trade-offs between architectural concerns and engineering efficiencies given the human goals. Feenberg (2002) again sensitises us to alternative substantive perspectives that might point to fundamental cultural tensions where the engineering method is applied to the creation of quality spaces for human experience, for which Arup's philosophy does not account.

5.2 Divisions between briefing, designing and construction

Arup objected to the rules and norms surrounding a persistent division between design (assigned to the architect and consulting engineers) and construction (the domain of the contractor who was absent from design). Again he argued that constraints on design undermined efficiency and quality:

> You cannot create designs for which the technical and constructional facilities do not exist, yet on the other hand no contractor is interested in creating facilities which are not yet called for by design…The architectural design is very largely the special interpretation of the client's wishes. The client himself does not really know what he wants before the architect has put pencil to paper and has shown the client what could be done ... wise decisions can only be based on a knowledge of facts, and this means that the technical adviser should be brought into the business…at an early stage. It is essential for economy that the design takes into account the method of construction as well as the final structure.

(Arup 1956, p. 2)

The means of construction embody particular knowledge, which must be integrated with the very first architectural design concepts. The transfer of this knowledge was a key problem. Clients were reluctant to collaborate in initial design stages that led to design briefs which were meant to articulate aims, preventing quality design (Arup 1972b. p. 3). Integrating construction considerations into the design briefing process would impose intellectual rigour on architects' responses to briefs, requiring them to "rationalise their purely whimsical predilections by reference to function or structural honesty" (Arup 1954 p. 29).

Arup called for design to become an interactive process involving both client and contractor. The client should formulate their brief alongside an exploration of design possibilities with the designer, and the designer should be closely informed by the contractor's knowledge of construction possibilities, processes and costs. This might also benefit the technology development process since it was typically down to contractors to develop new plant technology and construction techniques, and they derived their obligation for this from building designs (Arup 1965). Designs thus determined the technological development agenda for new plant and construction techniques. If design activity were more closely informed by construction possibilities, then the development of efficient technology and technique would itself become much more efficient. In Arup's view, the cultural objectives manifested in design briefs might define the character of technological means. That is, these means should be responsive to the human aims of technology expressed through design objectives.

This is how Arup arrived at the view that the design stage must permeate the building process with client, architect, engineer and contractor collaborating together. As the realisation of technical benefits for humanity was a moral imperative, so too was achieving this integration.

5.3 Specialisation and the limits to knowledge

A further barrier to the synthesis of design-pertinent knowledge across the industry was the specialisation resulting from scientific and technological advances. The ever broadening body of knowledge and technique was causing ever greater specialisation in all areas of the industry with no one group covering a wide enough field to discern all design information from often bewildering possibilities. Specialisation was necessary to deal with problems in a manageable way, but for Arup the danger was to forget the connections "so ruthlessly severed" (Arup 1970a. p. 391). Arup's characterisation of specialised views on any design correspond well with Bucciarelli's (2002) 'object worlds' which explain the different knowledge, values and languages of specialists in the design process. These again presented a barrier to the 'synthesis' that Arup sought between quality, form, and safe and efficient functionality.

Arup maintained that while any problem of design could be broken down into specialised parts only the whole or the totality of the parts expressed the ultimate aim, which was both "dream and action" (Arup 1969b. p. 514). In an industry where no individual or group covered a wide enough field to discern all design information, the creation of what he termed the 'composite mind' was key.

6. Total Design

6.1 The Total Design ideal

Arup's reflections are rich with detail on his efforts and experiments to develop his collaborative, 'composite mind' alternative to the fragmented approach he typically encountered. For the built environment this was 'Total Architecture'; more generally the term used was 'Total Design'.

> The term 'Total Architecture' implies that all relevant design decisions have been considered together and have been integrated into a whole by a well organised team empowered to fix priorities.
>
> (Arup 1970b., p. 1)

A design was the sum of all the decisions recorded and communicated in the form of drawings, sketches, models, prototypes and so on, covering all the facts that needed to be known and processes that needed to be gone through to achieve the aims that had been collaboratively explored. In line with his criticisms of current practices, this had to occur across:

- design perspectives (between both architectural and engineering disciplines *and* emerging sub-specialisms therein); and
- client/designer and designer/builder boundaries.

Arup freely recognised that integrated planning and design of this sort for the whole human environment was sufficiently lofty an aim never to be achieved, nevertheless he still explicitly stated this as the Total Design ideal (Arup 1970a.). In any case, if he and his colleagues strived to find what was needed for the best possible result in any single case, then what applied to one entity might well apply to most, as the need for proper integration of parts was a feature of all design (Arup 1970a.). Thus, experience gained in working towards any ('locally bounded') total design was valuable for extrapolation to large scales of built environment (Arup 1970a.).

This then was Total Design as a moral goal: the instrumental integration of high level aims with the most economical and effective means, which should ideally be extended to all scales of human-mediated environments. In this rationalisation of parts and whole, to be achieved through scientific and engineering method, and partnered with the proposed extension indefinitely across scales, we can see a firming up of Arup's ideas for urban design. We can also see Arup's instrumentalist conceptions of science, technology and design being extrapolated in a way that starts to parallel the tendencies noted by Mitcham (1994) within EPT traditions of thought.

At other times, Arup tackled aspects of what it is to be human, as when for instance he reflected on the nature of 'delight' fostered by architecture, indicating a wider scheme of thought that is conventionally associated with EPT. Furthermore, Arup never denied the social and political complexity of obtaining agreement about the desired character of the 'whole' to be achieved. Whilst he did not devise a sophisticated philosophy of the nature of technology and its implications for humanity, his conceptions about what it means to be human in a technological age underpinned his leadership of a large engineering practice and his formulation of principles for good design in the built environment.

6.2 Total Design in practice; implications for the firm

The organisational form of Total Design could only mean one thing; achieving committed collaboration and teamwork from the earliest possible stage between the client, the architect, the engineer and the contractor. The expansion of the boundaries of design teams and the overall firm to include other engineering disciplines was essential. Eventually, when the opportunity arose, architecture was also included within the growing 'Arup Group' with the establishment of Arup Associates. Only this approach could eliminate the barriers to quality design presented by the division of practices and responsibilities between architectural and engineering roles, between briefing, designing and constructing processes and between increasingly specialised expert groups.

With his colleagues, Arup sought to experiment with team arrangements for such collaboration. In an address to trustees, Arup compares two approaches to achieving Total Architecture. ‘Answer A’ involved “small multi-disciplinary teams with stable membership who get to know each other intimately and shed their sectional prejudices” (Arup 1973, p. 2). ‘Answer B’ consisted of separate, mono-disciplinary firms specialized in a portion of the design and co-ordinated by a project leader with an overarching view of the design, traditionally the architect (Arup 1973). He concluded that “To generalise about the organisation of the team is, however, quite impossible” (Arup 1970a., p. 396). Rather, the firm needed to develop the capability to deliver both approaches to design. In Arup’s view, this partly meant continued but carefully considered expansion –

> We are then led to the ideal of ‘Total Architecture’, in collaboration with other like minded firms or, still better, on our own. This means expanding our field of activity into adjoining fields - architecture, planning, ground engineering, environmental engineering, computer programming, etc. and the planning and organisation of the work on site.
>
> It is not the wish to expand, but the quest for quality which has brought us to this position.

(Arup 1970b., p. 1)

The move by an engineering consultancy to establish an architectural practice received criticism from architectural circles and concerns from Arup members who were worried about alienation of their existing collaborators. Arup's reflection on this again makes it clear that Total Architecture was always to be central:

> …our ideological commitment - if I may call it that - was to Architecture, and that meant Total Architecture, not just aesthetics. It was not to the architectural profession as such. And we knew that working as structural consultants only, our opportunity to pursue the ideal of Total Architecture would be severely limited. By working with our own architects who shared our ideas we would perhaps be able to make progress towards complete integration...
>
> (Arup 1972c., p. 13)

7. Aims and Means

Expansion to cover a wide range of specialist knowledge was not in itself synonymous with quality work. The Total Design model also necessitated a particular culture and set of attitudes, and eventually Arup and his partners became concerned over the impact of rapid growth on the core 'Arup values'. Collaboration and the appropriate fixing of priorities, Arup reflected, came only from mutual trust and respect for, understanding of and sympathy toward the work and perspectives of others. As the firm grew in terms of the specialisms and geography covered, Arup was prompted by his partners to make these attitudes explicit.

In the early 1970s Arup delivered a series of organisational addresses to the firm entitled 'Aims and Means', which led to the formulation and delivery of what became known as 'The Key Speech'. It reflects the challenge of devising an organisational form and culture around his Total Design ideal, as well as the usual management concerns associated with running a large and growing organisation. The moral tone is notable:

> By creating a model fraternity, so to speak, we make a contribution to what is almost the central problem of our time: how to overcome social friction and strife… We could become a small scale experiment in how to live and work happily together. This would also have a profound influence on the quality of our work.

(Arup 1969b., p. 514)

Arup explains his continual reference to aims, ideals and moral principles:

> … I do this simply because I think these aims are very important. I can't see the point in having such a large firm with offices all over the world unless there is something which binds us together. If we were just ordinary consulting engineers carrying on business… to make a comfortable living, I can't see why each office couldn't carry on, on its own... unless we feel that we have a special contribution to make which our very size and diversity and our whole outlook can help to achieve, I for one am not interested.

(Arup 1970b., p. 3)

Arup also makes a particular point of de-emphasising the importance of profit. This became embodied most clearly in when the firm was transferred into trust ownership on behalf of its employees in 1977. This was a considered decision to give the staff maximum freedom from short-term commercial pressures in the pursuit of the long-term integration of high level aims (Jones 2006).

This structure of the firm reflects what Michael Davis (1998) characterizes as an “engineer-oriented” company, as distinct from those that are “customer-oriented” and “finance-oriented”. Engineer-oriented companies are distinguished by their “general agreement that quality is the primary consideration (or rather the primary consideration after safety)” (p. 133). For such organisations quality in design and construction is placed centrally with profit-making as an enabling condition rather than a primary objective.

Since Sir Ove Arup’s death in February 1988, the firm has continued its geographic and disciplinary expansion. A copy of The Key Speech is given to every new employee which, in the preamble, states that the firm is still committed to the principles outlined within it, including Total Design, and that it is required reading for anyone who wants to know what the firm is “all about” (Arup Ltd in Arup, 1970b. p.1). With more than 10 000 staff in 37 different countries, it now includes engineering and related professionals working on all elements of building and infrastructure design, including; planning, economics, architecture, and project and management consultants, as well as a raft of technical specialists. The firm has contributed engineering design services for structures that include the Sydney Opera House, the Oresund link joining Denmark and Sweden, the Channel Tunnel Rail Link project connecting London to the Channel Tunnel which links England and France and, more recently in China, the 'Birdnest' stadium and 'Watercube' aquatics centre for the 2008 Beijing Olympics.

8. Conclusions

The firm that Sir Ove Arup established in 1946 has become a significant international consultancy providing a range of engineering design and related services. The extent to which this success can be attributed to Sir Ove's philosophy of design and his engagement with social and moral issues is a matter for further debate and exploration. The figure of Sir Ove, his 'Key Speech' and his theory of Total Design remain prominent in Arup's offices and are well known by Arup staff, but the degree to which his values and ideals are translated into everyday practice in the global context of the firm also deserves further investigation. These conclusions inevitably follow from our analysis of Sir Ove's writings, but do not detract from our primary aim, which has been to explore the work of a practice-based engineer-philosopher in light of fundamental categories of analysis in recent philosophy of technology.

Our purpose has been to analyse the particular issues that Sir Ove engaged with as a practice-based engineer-philosopher. The analysis shows some of the contextual influences on his thinking and provides insight into the organizational issues which underpin the practice of design for the built environment. A key part of this has been the utilisation of categories available for the consideration of moral and philosophical positions in order to foreground specific views against their broader alternatives.

Mitcham (1994) notes that the field of Philosophy of Technology, from which his categories of EPT and HPT emerge, is not well-defined, rather it engages with almost the full scope of heterogeneous problems traditionally of concern to philosophy, often with sharply contrasting aims and methods. To seek confluences in the ideas of one individual with those wholly positioned within one or other of these categories would be difficult and most likely unhelpful. This is especially so when dealing with practice-based thinkers whose positions are often not formally developed.

We have, however, described Arup's specific moral position and instrumentalist view on the nature and purpose of science and technological design in relation to social and political aims. Ultimately, Mitcham's work acts mainly to highlight the limits to the formal development of Arup's philosophical position when compared to other thinkers. This touches on areas associated with both EPT and HPT, but manifests itself most strongly in an organisational undertaking. Feenberg's (2002) work shows us more specifically that Arup's instrumentalism omits the possibilities raised by alternatives, which hold that "values of a specific social system and the interests of its ruling classes are installed in the very design of rational procedures and machines even before these are assigned specific goals" (p. 15).

Conditioned by his theoretical stance Arup developed a values-led agenda which focused on mitigating social contingencies impinging on design. This shaped his leadership and organisation of his firm and, at least in part, contributed to its 'engineer-led', quality-focused character through a particular model of (total) design. Ultimately Arup shows us that engineers often bring a complex mix of moral and theoretical perspectives, usually not formally expressed, to bear on their purpose and action. These can play an important role in how they individually and collectively define and orientate themselves around the challenge of achieving their design aims for human environments within the constraints and allowances of the socio-technical contexts in which they operate.

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