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Publisher: Taylor & Francis
Informa Ltd Registered in England and Wales Registered Number: 1072954 Registered office: Mortimer House, 37-41 Mortimer Street, London W1T 3JH, UK

Architectural Science Review
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tasr20

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Published online: 28 Oct 2014.

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To cite this article: M.S. Uihlein (2014): Ove Arup's total design, integrated project delivery, and the role of the engineer, Architectural Science Review, DOI: 10.1080/00038628.2014.963022

To link to this article: http://dx.doi.org/10.1080/00038628.2014.963022

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Architectural Science Review, 2014
http://dx.doi.org/10.1080/00038628.2014.963022

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Ove Arup's total design, integrated project delivery, and the role of the engineer

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(*Received 18 October 2013; accepted 4 September 2014*)

Sir Ove N. Arup's 'total architecture' was an organizational and philosophical set of guidelines for the working engineer, and at its best, it was a standard for the whole design team. In 2007, the American Institute of Architects created a system to implement integrative practice entitled 'Integrated Project Delivery' (IPD) to reorganize not only how a project team works, but when time is invested in designing. This paper examines the role of engineers in IPD through the lens of Arup's ideas, which are still seen as inspiration for practitioners. The philosophy behind IPD is examined through its definitive *Guide* and the application through a series of documented case studies. A comparison of Arup's philosophy and the structure of IPD demonstrates the position of engineers and how they are valued in an IPD project, leading to the conclusion that IPD falls short of capitalizing on the potential of the engineer as partner in integrated design.

Keywords: architectural design; engineering profession; integrated project delivery; integrated design; Sir Ove Arup

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Introduction

The *Encyclopedia of 20th–Century Architecture* lists Sir Ove Nyquist Arup as ' . . . arguably one of the greatest engineers of the 20th century' (Sennott 2004). Further confirmations of his stature are honours such as the awarding of both the Royal Institute of British Architects (RIBA) and the Institute of Structural Engineers Gold Medal. The Gold Medal by RIBA put Arup in a class that few engineers have achieved – recognition with the architectural community's highest honour for an engineer's contribution to architecture. Arup was a prolific writer and often spoke about the making of architecture, leaving a body of work on the topic of integration. He gained knowledge in engineering design and construction through architectural partnerships and his projects provided him diverse, yet complimentary experiences. He was also an observer, thinker, and communicator. Arup formulated ideas about practice which he would later call 'total design' or 'total architecture'. While he communicated his vision for the field through many venues, 'The Key Speech', given in the 1970s, is the best known. For Arup, 'total architecture' ' . . . implies that all relevant design decisions have been considered together and have been integrated into a whole by a well-organized team empowered to fix priorities' (Arup 1985a). At a minimum, this was an organizational and philosophical set of guidelines for the working engineer, and at its best, it was a standard for the whole design team. It gave meaning to the term integration and offered a way to approach one's work. His thoughts about collaborative work, begun as early as the 1940s, still provide an ideal for the role of the engineer within an architectural project. Echoes of Arup's aspirations can found in the writings and lectures of contemporary engineers seeking inclusion and a better standard of practice.

That Arup's comments remain relevant is further evident by their similarities with the Integrated Project Delivery (IPD) methodology, a system created by the American Institute of Architects (AIA) in 2007 to implement integrative practice. The development of IPD was an attempt to reorganize not only how a project team works together, but at what stage design time is invested. This method promises to create collaboration and improve the quality of architecture. For those who are passionate about integrated design, there is much hope for this delivery method and the potential for change it brings. The success of IPD will rest on many things – its adoption by the field of architecture, quality projects that can be attributed to the delivery method, and its inclusion of the architect's partners in the design process. This paper examines how structural engineers, those normally attributed as 'others', are incorporated into the design process by IPD, by investigating the delivery method through integrative objectives identified by Ove N. Arup. Arup, while not the only successful or creative structural engineer, provided a well-considered and internationally acknowledged body of work in terms of integrative guidelines and built projects. Arup's benchmarks provide a mechanism for evaluation in order to

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answer the question: does IPD really promise a better position for consulting engineers, which Arup saw as crucial to the success of a project? Important commonalities between Arup and IPD include project conceptualization, process, and teamwork and these links demonstrate that further connections are possible in the design process for the engineer. However, analysis of the IPD implementation document and IPD case studies authored by the AIA reveals that the marginalization of the engineer continues to be institutionalized and systemic. While moving beyond the stereotypical ideas such as engineers not understanding design, the engineer is nevertheless intentionally relegated to a second tier, or worse, not considered a valid contributor. If integrated design is to become a standard, and practice is to move from a divided and inefficient design process, then the further incorporation of engineers and their skills will be necessary. IPD is a step forward, but the project delivery method has yet to include the whole design team.

Arup's story

An early professional position for Arup was with the Danish firm, Christiani & Nielsen, where he worked with a relatively new material – reinforced concrete. At that time, the design of concrete was still being developed, understood, and codified. In addition to design, Arup's work included construction, which he would find invaluable and carry with him throughout his professional life. This experience is embodied in his ideas and noted in his speeches: 'Good design should embody a *sensible* way of building' (Arup 1966). Arup's introduction to architecture with a capital 'A', as he has described, began when he worked as a consulting engineer with the modernist architect, Berthold Lubetkin and his firm Tecton (Arup 1966). Together they completed multiple projects including two small ones for the London Zoo. The first of these was the Gorilla House (1933), which was followed by the better known Penguin Pool (1934). Completed with Lubetkin in 1935, Arup identified his first major building as Highpoint One. This project was deemed a success by the architectural community as a new model of residential living, and it was here that Arup observed Tecton's 'exhaustive designing' as they studied not only details but ' . . . every piece of equipment—and redesigned most of it' (Arup 1985a). Of this iterative process Arup observed, 'I was surprised at the trouble he [Lubetkin] took over every detail . . . .For him, architecture was a battle to be won with every means at his disposal' (Arup 1966). The relationship between Arup and Lubetkin provided a close interaction of the ideals of architecture and the successful physical manifestation that came after intense interaction of the two men – architect and engineer. For Arup, it was also an opportunity to bring his previous experience to the project and add value. He proposed a system that had been used in his civil projects – structural walls and slabs instead of the standard beam and column system. This 'new' structural system gave options to Tecton. Constructability, architectural design, and structure as building technology were combined to great success.

Arup found this type of professional and ideological exchange novel and rewarding. When Arup began practicing, the ' . . . structural engineering of buildings was mainly handled as a sideline by civil engineers, who did what architects asked them to do and no more' (Thorne 1966). Supporting structural design for architects was not a priority and ' . . . an engineer possessing such convictions in 1930s England was a very rare phenomenon indeed' (Arup 1995). That is not to say that other engineers did not probe the established methods of practice. Owen Williams (1890–1969), who would work both as an architect and engineer, and Felix Samuely (1902–1959), who worked for Arup at an earlier firm before starting out on his own, were two such engineers (Bernabeu 2006). However, Andrew Saint, author of *Architect and Engineer: Study in Sibling Rivalry*, confirms that Arup was the primary symbol of this 'new kind of collaboration' (Saint 2007). Saint, though critical of Arup, further described him, 'Through personal example . . . this now-consecrated figure [Arup] stands for a fresh pattern of partnership between architect and engineer' (Saint 2007). Author William Addis posits that Arup's ideas of 'total design' can be seen as an evolution from the architecture and engineering partnerships in the nineteenth century when a tradition of innovation in British engineering existed (Addis 2007). Arup's development of 'total design' came about as he tried to change the mechanism in which architecture was created.

Applying total design

With his ideals set, Arup became known for his speeches and consideration of practice; he also acted on his ideas, which in turn allowed for further observation and refinement. In 1946, Arup began his design firm to create a forum for forming teams with unified aims. It was an intentional decision to leave behind the contracting aspect of his practice. This allowed Arup to take advantage of his skill set and combine it with his desire to work with architects. Peter Jones, Arup's biographer, suggested that Arup and his firm were able to address some of the issues Arup raised in 1942 when he stated, '[Modern buildings] are often badly planned, badly ventilated, badly heated, etc. In other words, only limited use is made of all the existing technical knowledge' (Jones 2006). As Arup saw it, collaboration was required between architects and engineers to make 'good' buildings, and building technology was an influence in the quality of building design. Though it began as a structural consulting practice, the firm later added other engineering disciplines. By adding building services, Arup's firm could produce multidisciplinary engineering teams and partner with architects.

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Arup's other great experiment arrived with the establishment of Arup Associates in 1963. In October of that year, Arup wrote a letter to his clients announcing a new group within Ove N. Arup & Partners. As he announced, Arup Associates was ' . . . a formation of a new partnership of Architects and Engineers . . . who undertake the total design of buildings' (Brawne 1983). It was the official launch of something that had been incubating in Arup's firm for several years. Arup Associates was a firm that had placed architecture *and* engineering on equal footing to bring about 'true collaboration'. To achieve this, existing professional barriers had to be challenged within the industry and the firm's own environment. Arup Associates was an evolution of his ideas and remained influential. In his RIBA Gold Medal address, Arup referred to the firm:

> It has confirmed my contention that art and sensible building can be combined without detriment to the former. In a team working for a common purpose in a friendly atmosphere, it can happen that something emerges which is more than the sum of the individual contributions. (Arup 1966)

Arup's practices were meant to bring engineers more carefully into a project by providing every opportunity for their input and including them in the central design team.

Total design – the embedded characteristics

The succinct form of Arup's 'total design' was documented in a speech that he delivered at the age of 75, called the 'The Key Speech'. With this work, Arup attempted to pass his vision of the firm onto the next generation, but its influence goes beyond the company Arup established. It was here that he summarized 'Total Architecture' as an aspiration for all – including the work of his fellow engineers. Though Arup conflated the two terms 'total architecture' and 'total design', it can be seen from his body of work that 'total design' is full of meaning beyond the definition he gave in this speech and represents years of his exploration. It encapsulated Arup's approach to a project, included his standard of integration, his views on collaboration, and his aspirations for architecture. The specific characteristics of Arup's vision for engineers can be found through an examination of Arup's speeches and papers, falling into three main categories – conceptualization, process, and team parameters.

Conceptualization

An integrated project, for Arup, began when the project was conceived. The concept was created by the architect with engineers contributing, and it incorporated the traits of construction, building technology, and efficiency – financial and material. The individual components of conceptualization as identified by Arup are described below:

- *Shared Goals*: This is the expectation that engineers will be involved with the whole of the project, be committed to seeing that aspirations are met, and work towards excellence. As Arup described: 'The first condition is that all members of the team subscribe to this aim that they all want to help produce good architecture, architecture in depth . . . ' (Arup 1985c, 9).
- *Incorporation of construction knowledge*: Aspects of the making of the building are included in the foundational ideas of the project rather than waiting until the project is under construction. As Arup emphasized: 'Of special importance is the close connection between design and execution' (Arup 1985e, 16).
- *Cost, efficiency, and ease*: The qualities of refinement and elegance are incorporated into the aims of the project and used as evaluating guides to proposed solutions. Along with the knowledge of construction, an architect must understand the cost implications of the design decisions being formed. Otherwise, the sensible building, as Arup described, would be lost (Arup 1966, 352). The engineer was responsible for helping the architect understand this.
- *Quality as a guiding principle*: Quality work is an intended outcome of the project which informs how the pieces are envisioned and realized. Arup urged his firm to pursue these aspirations, 'We must therefore strive for quality in what we do, and never be satisfied with second-rate' (Arup 1985a, 34).
- *Access for the engineer to the ideation of the project*: Engineers are permitted and have the ability to use their skills, talents, and intellect to contribute to the formulation of the project as well as address some of the overarching ideas. This point is to overcome the separation of the engineer from the project due to the fact that the consulting engineer ' . . . is not even appointed . . . ' (Arup 1959, 500) when needed by the architect and to provide the architect access to technical knowledge.
- *Delightful and meaningful architecture*: Referring to Arup's capital 'A' architecture and Vitruvian delight, the formulation of the project must consider the impact to the owner, user, and society as a whole. The objective is to provide a building of substance, character, and wonder. If everyone involved, ' . . . could join in wanting to create total architecture in the best sense . . . then our joint efforts, in whatever combination, might be able to create a better environment for man' (Arup 1966, 359).
- *Building technology as a contributor*: This is the idea that the attributes of building systems can be included in the shaping of a project beneficially

rather than burden the project with requirements. For example, Arup saw that structure could enhance a project so that 'architectural harmony' (Arup 1985e, 16) could occur.

'Total architecture or total design' implies a level of execution in a building that serves many and has, as Arup wrote, an artistic or 'spiritual' quality to the work (Arup 1985b). Along with cost awareness, technical integration, and teamwork, Arup wanted for himself and the people in his firm to always have dedication or 'enthusiasm' for their work. As Arup suggested, it was not enough that everyone should have high objectives for their own work. The entire team should also be committed to the whole project.

Process

A portion of Arup's work was simply to question the overarching manner in which architecture was made. Whether it was contracts or intentions, he was, in essence, asking the existing systems to be examined and restructured. Beyond these challenges, Arup also sought to improve certain aspects in the design process including timing, communication, and synthesized resolution. Further definition of these crucial pieces follows:

- *The questioning of engrained work methodologies*: The argument here is that the established work methods are not integrative and therefore are to be examined as well as altered in order for integrative work to occur. As Arup observed, 'The fact is . . . that the technical revolution in the building industry has outstripped the organization which was devised to cope with a much simpler form of building' (Arup 1959, 501). The prescribed relationships between the architect, engineer, owner, and contractor were out of line with what practice demanded.
- *Project role re-definition*: The existing project roles are created, understood, and practiced based on systems which inherently prohibit integrated design. Therefore, the role of each profession must be reconstructed to allow for more expansive participation. Recognizing the difficulty in this, particularly when he was setting up Arup Associates, Arup stated, 'The members of the team must even be educated to understand what it means' (Brawne 1983, 7).
- *Early involvement of team members*: As outlined above in 'Conceptualization', the input from multiple team members allows for good pathways to be determined. For the success of the project, the timing of the contributions is to be as early as possible. Arup noted that ' . . . the architect should have his technical advice even before he starts sketching out his first conception of the job' (Arup 1959, 500). Otherwise, the engineer might be left with a project that would be difficult to make work technically and would not be integrated: ' . . . harm done by hasty or ill-considered initial decisions maybe difficult to undo' (Arup 1959, 501).
- *Open communication*: As much as professionally possible, team members have an unrestricted ability to share ideas, to receive project information, and to provide input to others. This free access ensures that the correct people receive the information in addition to levelling the hierarchy of the project team. Referring to the 'ideal design team', Arup suggested that, 'Even the professional demarcations may fall away – at least in the discussion of the main design decisions' (Arup 1985b, 32). This breaking from traditional expectations allows engineers to contribute significantly to the design without the limits of professional boundaries.
- *Synthesized resolutions*: As described in the Key Speech, the choices made for the project are weighted with the priorities of multiple disciplines and yield a solution that is richer than one for its own sake. In order for these opportunities to occur, the architect was to ' . . . have all the technical information which may have a bearing on the problem checked up, classified, standardized, and made easily available' (Arup 1985e, 16). Only then could ideas and systems be combined for a better result.

Integration was, for Arup, the culmination of decisions that led to the layering of parameters which enabled the design to work technically and be architecturally significant. The parts must be individually very good, but on their own they were nothing. It was only their relationship to the whole that brought them their original value and then added to it. The team of designers –architects and engineers – working together enabled this type of designing to occur.

Team

Arup also had some very specific requirements for collaboration and team composition. He understood that an integrated process comprised individuals who worked together as a team to bring the larger ideas to fruition. His ideas are listed more fully here:

- *'New' types of collaboration*: Integrated design requires collaboration among team members. However, as the architectural, engineering, and construction (AEC) industry is not accustomed to crossing disciplinary boundaries, a new way forward must be recognized as needed and new skills developed. ' . . . [T]he importance lies in the fact that the various experts are in constant close co-operation and learn to understand each other's points of view,

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so that each can see his work as part of a whole plan . . . ' (Arup 1985e, 16).

- *Trust and respect*: Professional relationships allow for integration to occur and interactions among the practitioners benefit from an appreciation of one another and the work they have to do. Collaborators were to be small teams of people, who knew each other's abilities, ' . . . but what is absolutely necessary is that they should respect each other, each other's point of view. They should recognize that each has a valid contribution to make . . . ' (Arup 1985b, 31).
- *Open boundaries*: Barriers are naturally built into a team structure due to training and expected professional roles. Effort must be put into the project by the team to identify and work through that which would prevent integrative work. While Arup clearly recognized divided roles, the positions should be closer together. It would be best if ' . . . the architect should be part engineer and the engineer should be part architect in order to achieve a fruitful collaboration' (Arup 1959, 500).
- *Engineer as 'Partner'*: The engineer functions more broadly in a team, moving beyond concentrating on a set of calculations to thinking and acting for the whole of the project. This requires that the engineer expand their skills and that the architect receives the engineer's input. If not leading the project, according to Arup, the engineer was to ' . . . be a partner in evolving the design, so that the proper integration of structure and architecture can be achieved . . . ' (Arup 1959, 500).

Included in Arup's concept of collaboration were articulated roles for the engineer and the architect. The architect can ' . . . create overall balance to assess priorities . . . . ' (Arup 1985c). The architect was also to fulfil the role as the leader on the project, possessing a sufficient intellect and ' . . . gathers all the threads together and makes the decisions . . . ' based on the vision of the project (Arup 1985d). Engineers have the responsibility to contribute to the whole of the project. Arup, therefore, was critical of engineers who never left the comforts of their calculations, and he pushed for a more active and engaged engineer. If these roles are followed, the architect has a chance to bring 'delight' or 'the intangible values associated with good architecture' to the project (Arup 1985c).

One of the reasons Arup's ideas about design and engineering remain relevant is that they are multifaceted. Arup focused not only on the concept, but how one got there and the end results. People were considered in addition to technology. At the same time, Arup's ideas were the observations and thoughts of one man, who while quite influential, did not have the power to guide the whole industry. He implemented his concepts where he could, in his own firms, but the rest of his impact was inspirational. Lectures were conversational and connected with practitioners who had similar experiences as himself. While Arup saw that other professionals were interested in his lectures, he understood that change would come only with structural changes and these were beyond his reach (Arup 1985e).[1] In the 'Key Speech', he identified that striving for excellence led to better architecture and if team members worked on quality projects, they would be more satisfied, and value their time at work as much as their personal time. This personal pride in and commitment to a project would necessitate the engineer to invest in the larger ideas and bring rigour to every piece of the work. However, for engineers to be effective, they also have to be allowed the chance to participate fully. The characteristics identified above give an indication of how Arup strove to have the engineer included.

IPD – the philosophy of a new method

Like Arup's total design, IPD was intended to challenge the design process by restructuring how buildings come together. In the USA there are several project delivery methods that, through contracting agreements, dictate the composition and hierarchy of a project team. Design-Bid-Build, which is often referred to as 'traditional' practice, Design-Build, and Construction Management at Risk are the three major systems today (American Institute of Architects and Associated General Contractors of America 2011). IPD is intended to be a fourth. The launching of this delivery method was timely with a focus in the field already occurring on building information modelling and the intentional consumption of resources, both of which are specifically identified as beneficial in the IPD document. The economic pressures beginning in 2008 and still felt today added to the pressure for the AEC community to reform the way it works. The standard contractual method, Design-Bid-Build, sees the project owner hiring the architect, who in turn hires various consultants such as the multiple engineers needed. The architect leads the team in the project design with its articulation getting more refined through each of the project levels. Once the design is 'completed', the owner hires the contractor to build the project. This 'over-the-wall' approach, where the design team passes their drawings over the divide to the contractor, has been found to be wasteful and counterproductive costing the economy billions (Elvin 2010). *Integrated Project Delivery: A Guide,* published in 2007, explains the new project organizational system and the AIA's intentions are quite bold as described:

> It may set all who believe there is a better way to deliver projects on a path to transform the status quo of fragmented processes yielding outcomes below expectations to a collaborative, value-based process delivering high-outcome results to the entire building team. (American Institute of Architect 2007)

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IPD seeks to move from the traditional segmented work patterns to one that is integrative and inclusive.

The changes that the AIA proposes are to improve the final product and how one expects to work. Work phases have been reorganized and given new names. The intent is to allow one to imagine a new way of working and provide an opportunity to create novel expectations for roles. Gone are the conventional American terms 'schematic design', 'design development', 'construction document', and 'bidding' phases. Instead 'conceptualization', 'criteria design', 'detailed design', 'implementation documents', and 'final buyout' describe the work flow. Emphasis has been placed on making important design decisions earlier with the inclusion of the contractor from the beginning. The roles that the practitioners take are redefined with the contractor renamed the 'Constructor' and the 'Designer' for the design lead, which allows for the role to fit the architect or someone else that may be appropriate for that position. The 'Integrated Project Coordinator' has become a unique and separate position. While an outside member of the team may hold this post, it can also be held by the designer or constructor at different points within the same project. Overall, the change in terms for the project stages appears more successful than those of the project participants in terms of re-envisioning the work flow. Owners, constructors, designers, and design consultants do not lead one away from the long-defined owner, architect, and contractor positions within a project. The term 'Criteria Design' does reframe how one looks at defining the initial ideas of a project. The new work stages, the reframing how and when a project is conceived, and the redefining of roles are all meant to remove wastefulness in the process and ultimately improve the final product through integrative design. The success of the method is still being determined.

To examine one aspect of IPD, two analyses are presented here evaluating the position of the structural engineer within IPD. The first examined its intentions and goals in the directive document, *Integrated Project Delivery: A Guide;* the second studied the set of case study projects using IPD and promoted by the AIA to demonstrate its potential. To begin, the *Guide* is evaluated through the earlier categories of conceptualization, process, and team parameters, providing a deeper understanding of the methodology and its intents.

Conceptualizing a project under IPD

Like Arup, IPD has given a greater weight to the initial steps in a project's creation. Utilizing the MacLeamy Curve among its evidence – which demonstrates the ability to provide the greatest impact at the least cost at the beginning of the project – the AIA argues for moving the bulk of the design process forward. The first phase, named 'Conceptualization', establishes and includes more outside input than under previous methodologies and sets up 'Criteria Design' to tackle major decisions. Integrative work happens from the beginning. Key features in the origins of an IPD project are:

- *Shared goals*: By determining goals jointly, the team is making expectations plain as well as forming implicit concurrence among the members as to where the project is heading. This definition places ' . . . project outcomes at the center within a framework of individual participant objectives and values' (AIA 2007, 5). Shared aims are structured into the project delivery method.
- *Incorporation of construction knowledge*: Acting on the criticism that vital information of how a building is made is often received when it is costly and too late, those that have this knowledge are brought in contractually from the start. This creates a mechanism in which the guidance is purchased and provided during the time when ideas are formed and solidified. 'The integrated delivery process allows constructors to contribute their expertise in construction techniques early in the design process resulting in improved project quality . . . ' (AIA 2007, 3).
- *Cost, efficiency, and ease*: Embedded in the project formation is a particular goal for the design to thoughtfully include efficiencies. 'Thus the thrust of the integrated approach is not to reduce design effort, but rather to greatly improve design results, streamlining, and shortening the much more expensive construction effort' (AIA 2007, 6). Everyone on the team acknowledges these ambitions from the start of the project.
- *A focus on the team*: The team is formed and agrees to work within a process which acknowledges that the success of the project is based on the combined work of all of the team members. This approach mandates that each member's contribution take into account the impact on the whole and that the team consider the individual input seriously from the start. IPD instils this sense of responsibility through shared risk and reward. 'Compensation . . . rewards "what's best for project" behaviour, such as incentives tied to achieving project goals' (AIA 2007, 5).

Phrases such as 'sea change' embody the AIA's desire to create a bold, new type of practice. Rather than hope for a good group of practitioners who want to collaborate, IPD proceduralizes steps to ensure it. Individuals will not fail or succeed – the project will – and hence, all are subject to the pain of a poor project result or benefit from the financial incentives of meeting the team's targets. Important to the realization of an integrated project is that influencing ideas are conceived jointly.

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The IPD process

An analysis of the content of the *Integrated Project Delivery: A Guide* can lead one to say that IPD is solely about process because there is such a strong emphasis on it. The final goal of an integrated building cannot be achieved if the means of designing it are not integrative. Project development is to include an open exchange of ideas and information, sharing by all, and as early as possible. The necessary components are:

- *The questioning of engrained work methodologies*: An evaluation of standard practice found it wanting. Integrated projects can occur under existing structures, but with difficulty. Traditional 'separate silos of responsibility that … yield inefficiencies' (AIA 2007, 7) are preventing good work from happening. The process itself then must be challenged and changed. This provides justification for IPD itself.
- *Project role re-definition*: Project participants are expected to have a higher level of involvement and include those who are normally excluded from ideation. Traditional roles restrict the mindset of individuals towards an integrative process and thus need to be reconfigured. 'IPD strategically realigns participant roles, underlying motivations, and sequences of activities on a project to utilize each participant's best talents and abilities at the most beneficial moment' (AIA 2007, 7).
- *Early involvement of team members*: Vital information has been found to have been excluded from project formation due to a lack of access. The IPD process recognizes this omission and is structured to be inclusive. 'In an integrated project, the key participants are involved from the earliest practical moment' (AIA 2007, 5), often due to changes in contractual arrangements.
- *Open communication*: If the currency of design is ideas and information, then both must be allowed and encouraged to flow freely. '[C]reating an atmosphere and mechanisms that facilitate the adequate sharing of information between and among team members is essential …' (AIA 2007, 10). Project environment is a priority and is to be addressed within the project organization.
- *Joint decision-making*: Multiple team members provide and evaluate the attributes in which decisions are made. The case here is that requirements cannot be arbitrarily discarded, but rather consideration is necessary. '[A]ll decisions are made unanimously by a defined decision making body' and '… in the best interest of the project' (AIA 2007, 9). A decision-making team is established to act on this principle.

IPD promises a more holistic project by articulating and confronting specific areas such as risk, reward, and communication. Decisions are to be resolved with one voice. Communication is to be 'open, direct, and honest' and the team is to create, partially through procedures, a 'no-blame culture'. Simultaneously, the delivery method has identified difficult factors in traditional practice which when improved upon have the potential to enrich building design.

The IPD team

Beyond the principles of the method, the AIA gives guidance on establishing a project, including the development of the project team. The method guide used proactive language such as 'envisioning a new world' or removing 'adverse and antagonistic relationships' bringing together 'all participants' in the principles of this method (American Institute of Architect 2007). With the delineation of team members the method gets into more specifics on how the work of the participants is envisioned. These concepts are:

- *'New' types of collaboration*: Traditional methods of design are '[l]inear, distinct, segregated; knowledge gathered "just-as-needed"; information hoarded; silos of knowledge and expertise' (AIA 2007, 1). IPD recognizes the faults of the current practice and proposes to change how practitioners work together based on distinct components. New and re-envisioned working relationships are essential to create significant change.
- *Trust and respect*: The characteristics of a professional relationship are seen as the principles on which the entire method is founded. Integrative work cannot happen unless team members are agreeable to it and this willingness occurs when there is a safe environment to do so. 'Without trust-based collaboration, IPD will falter and participants will remain in the adverse and antagonistic relationships that plague the construction industry today' (AIA 2007, 5). These interpersonal traits are specifically listed to emphasize their role.
- *Primary participants*: As the name suggests, these team members form the top level of a project, are responsible for it, and are the 'project's decision making body' (AIA 2007, 9). They are thought to have an extended role in the project, and are to be involved from the initiation to the end. The owner, architect, and contractor constitute this group.
- *Key supporting participants*: 'Key' implies that these roles are important and necessary to the project while 'supporting' identifies their secondary position. These supporting participants are to 'perform discrete functions' (AIA 2007, 8) and provide advice to the primary participants. Engineers as well as

subcontractors are identified with as key supporting members with structural engineers being used as the example. This type of team member is not perceived to be involved beyond the area of their expertise, and the duration of their contribution is seen as limited.

- *Engineer as consultant*: Defined as those who support and contract directly with primary participants, engineers remain in the position of the design consultant. Consultants in addition to their 'specific areas of work', they ' . . . understand the value of collaboration and are committed to working as a team in the best interests of the project' (AIA 2007, 5).

Given the emphasis in IPD on the 'realigning' of project roles in order to facilitate integration, the delegation of responsibilities is important in understanding the intent of the method and the extent of changes to practice. By placing the owner, architect, and contractor in a group together, a traditional dynamic shifts and there is the possibility of alignments. Key supporting members ' . . . agree to be bound by the collaborative methods and processes . . . ' established by the primary members to raise the quality of the project (American Institute of Architect 2007). Teamwork is at the core of IPD with the team defining initial project ideas. Project organization and process do not create 'artificial barriers that chill open communication and risk taking', but instil the need to embrace the priorities of the owner, architect, *and* contractor (American Institute of Architect 2007).

Examining the position of the engineer within IPD, however, the profession has not been addressed directly beyond the assignation of their secondary position and arrangement in project stages. Engineers are further left out from the text that defines this new vision of practice, while contractors and facility managers are included. The engineer is envisioned to have a short, defined, and supporting contribution and removed from decision-making. Between team member definition, omissions, and reverting to traditional practice expectations, the 'new way forward' for engineers in integrative architectural design is unclear from the IPD *Guide* and principles. Loosely speaking, IPD is seeking to bring everyone together for the sake of the project. However, the articulation of the method seemingly contradicts these aims in regards to the engineer.

IPD – case studies

A further evaluation of IPD comes through an analysis of the case studies that the AIA, through their website, promotes as examples of the methodology at work. Two documents, *Integrated Project Delivery: Case Studies* (2010) and *IPD Case Studies* (2012), present the projects and analysis of the delivery system (AIA/AIA California Council 2010; AIA, AIA Minnesota, School of Architecture – University of Minnesota 2012). For the earlier work, projects were selected based on project type, compliance with selected IPD criteria, and geographic location; the latter chose projects based on expanding the variety of projects and range of team experience (AIA/AIA California Council 2010). The 2010 set used interviews, including engineering consultants, and data collection, while the expanded 2012 study conducted a survey with 127 participants responding. The 2010 projects appear to be adopted in the 2012 report without further research as no surveys were conducted. Table 1 lists the projects studied, their source, and the size of the project.

Using the three main categories and the subthemes identified in the philosophy of Arup and IPD, the selected case studies were investigated for indications of the subthemes being enacted and the inclusion of the structural engineer in the project. The role of the engineer was considered through identified project management structures or through direct statements addressing the topic. It is possible, for example, that the project included joint decision-making, but structural engineers were not included in the decision-making body as described in the Primary participant classifications. This subtheme is noted as occurring as well as the exclusion of the structural engineer through the use of symbols. On a few occasions, mechanical, electrical, and plumbing engineers were addressed and this was noted. The findings are summarized in Table 2.

The table can be analysed on two levels: first, examining the role of the structural engineer in IPD and, second, the adoption of Arup's integration characteristics. The first of the conclusions about the engineer is that the profession has not been thoroughly considered. This can be seen through the omission of the structural engineer in most project descriptions. A third of the case studies do not identify if a structural engineer has been engaged or by which contractual relationship (an inclusive IPD contract or standard consulting). In other examples, the presence of the structural engineer is known only though a brief mention or listing in a table. This finding is not to provoke the idea that engineers should be getting credit for their work, but rather the absence of the structural engineer in the case study research indicates that their input was not considered in the success of the application of the delivery method. Additionally, there is a general imprecision within the studies as to how engineers participated. A distinction was made in the leadership of the project, and it can be seen that the primary participant structure was used in three-quarters of the case studies. However, when it came to the use of the term 'team', it was unclear as to which parties were included. In all cases when an engineer was engaged (any), this project member was identified in a secondary role as a consultant with his or her involvement in shared goals, role redefinition, and in a new type of collaboration, generally uncertain. Perhaps the structural engineer was included in team building exercises and benefited from open boundaries, but it cannot be determined

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Table 1. AIA case studies on IPD.

Project	Integrated project delivery: case studies	IPD case studies	New construction	Remodel/Tenant improvement	Structural engineer used?	Project size
Cathedral Hill Hospital		x	x		Yes, contracted to architect	79,711 sm
MERCY Master Plan Facility Remodel		x		x	Not stated, assumed 'Yes'	8774 sm
Lawrence & Schiller Remodel		x		x	Not stated, assumed 'No'	650 sm
SpawGlass Austin Regional Office		x	x		Not stated, assumed 'Yes'	1428 sm
Edith Green Wendell Wyatt Federal Building Modernization		x		x	Not stated, assumed 'Yes'	48,813 sm
Autodesk, Inc.	x	x		x	Yes, not in joint contract	5110 sm
Sutter Health Fairfield Medical Office Building	x	x	x		Yes, A/E Firm	6498 sm
Cardinal Glennon Children's Hospital Expansion	x	x	x		Yes, A/E Firm	12,821 sm
St. Clare Health Center	x	x	x		Yes, A/E Firm	39, 948 sm
Encircle Health Ambulatory Care Center	x	x	x		Yes, A/E Firm	14, 586 sm
Walter Cronkite School of Journalism	x	x	x		Yes	21,368 sm
UCSF Mission Bay Medical Center		x	x		Yes	81,569 sm

Source: (AIA/AIA California Council 2010 and AIA, AIA Minnesota and School of Architecture – University of Minnesota 2012).

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from these documents. With larger construction and hospital buildings, structural engineers would have a significant responsibility in the design of the project, and it is hard to imagine that they were excluded. At times, engineers were grouped in with the 'A/E' team, implying equal footing with the design team, though there is no evidence that the engineer's role expanded. When there was more than passing reference to engineers at large, they were often referenced as not participating. For instance on the UCSF Mission Bay Medical Center, '[t]he architect observed the engineers struggled most with culture change that affected traditional relationships and hierarchies' (AIA, AIA Minnesota, School of Architecture – University of Minnesota 2012). Also note, in the 2012 study survey, engineers described the effect of IPD on the project as 'only somewhat' positive. There is dissonance when it comes to structural engineer involvement. IPD appears to be a new method with laudable goals, but one where the engineer or project does not see an impact on their involvement.

The table also reveals an observable distinction between which of Arup's factors were adopted and which were not. The factors that were jointly defined by Arup and the IPD philosophies were nearly wholly adopted with an exception being role redefinition and trust/respect only being emphasized three-quarters of the time. Four subthemes were utilized in every project: incorporation of construction knowledge; an emphasis on cost, efficiency, and ease; new types of collaboration; and a new methodology was embraced as the way to design. This indicates that a portion of Arup's ideas have found acceptance and implementation within IPD. Each of these case studies, for example, demonstrated the increased involvement of the contractor and subcontractors at early stages and the value this inclusion brought through interactive costing and design decisions (see construction knowledge and early involvement subthemes). The results give some validation that the new delivery method is helpful in an industry dogged by inefficiencies due to the late incorporation of the contractor. Predictably, the categories that were not included involved those with a greater role for the engineer such as building technology as a contributing factor to architectural design and the aim for synthesized design decisions involving these technologies. Thus, Arup's idea of the engineer as a partner in integration falls flat as does the ability for the engineer to contribute to the larger ideas of the project. More surprising, however, is the failure to embrace meaningful architectural design, even when design is the focus of the AIA's vision, and the emphasis on

Table 2. Analysis of AIA IPD case studies.

	Conceptualization								Process						Teamwork					
	Arup				Shared Themes			IPD	Arup	Shared Themes				IPD	Arup		Shared Themes		IPD	
	Access to Ideation for Engineer	Emphasis on Quality	Meaningful/Delightful Architecture	Building Technology as a Design Factor	Shared Goals	Incorporates Knowledge of Construction	Cost, Efficiency, and Ease	Focus on Team	Synthsized Resolutions	New Methodology used in project	Role re-definition	Early Involvement	Open Communication	Joint Decision-Making	Open Boundaries	Engineer as Partner	New Collaboration	Trust and Respect	Primary Participant Structure	Engineer as Consultant
Cathedral Hill Hospital					○	■	■	●		■	○	○	●	○	○		●	○	■	■
MERCY Master Plan Facility Remodel		●			●	■	■	●		■		○	●	○	●		●	●	■	■
Lawrence & Schiller Remodel					○	■	■	●		■	○	○	○	○	○		○	○		
SpawGlass Austin Regional Office					○	■	■			■		○		○			○	○	■	■
Edith Green Wendell Wyatt Federal Building Modernization				○*	○	■	■	○*		■	○	○	○*	○*	○*		○	○	■	■
Autodesk, Inc.		●	●	○	○	■	■	○		■	○	○		○	○		○		■	■
Sutter Health Fairfield Medical Office Building					○	■	■	○		■	○	○	○	○	○		○	○	■	■
Cardinal Glennon Children's Hospital Expansion						■	■	○*		■	○*	○*	○*	○*	○*		○*			■
St. Clare Health Center					○	■	■	○		■		○	○	●	●		○			■
Encircle Health Ambulatory Care Center					○	■	■	○		■	○	○	○	○	○		○	○	■	■
Walter Cronkite School of Journalism					○	■	■	○		■	○	○	○	○	○		○	○	■	■
UCSF Mission Bay Medical Center					○	■	■	○		■	○		○	○	○		○	○	■	■

■ Yes. Considered as a 'Yes' or 'No' in terms of project application, regardless of engineering role

● The structural engineer was included in this aspect of the case study

○ Addressed, but inclusion of structural engineer is not apparent

* Inclusion of MEP engineers noted

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a quality in a project, where only two projects listed this as a stated goal. The project type might provide some insights into these exclusions with health care a majority of the case studies and projects identified as using this methodology by the reports (AIA, AIA Minnesota, School of Architecture – University of Minnesota 2012). Cost, time to completion, patient satisfaction, and excellence in clinical care were called out as goals (AIA, AIA Minnesota, School of Architecture – University of Minnesota 2012). Only one project listed design quality as a stated objective. The collection of case studies gives some credence to criticism of the method as one that removes architectural design as a priority. Overall, IPD projects appear to benefit from some repositioning of work stages, re-evaluating professional positions, and inclusion of the contractor. The full possibility for integration and collaboration stop short of being realized, however, without the recognition of the potential contributions of building engineers.

Conclusion

Through his professional relationships and his observations of architecture, Arup came to realize that there was more to a building than structural design and construction. He had something to contribute beyond being a consultant and wanted to fulfil his responsibility to the larger world. His concept, 'total design', created a true partnership between the architect and the engineer in order to create better architecture. 'Total design' calls for all contributions to be evaluated, weighed against each other, and a decision made that embodies several of the characteristics of the individual contributing factors including technology. He called for a team that works together efficiently where members understood their roles and the roles of others, with each member's position seen as necessary for the greater good of the project. This level of integration involves the multilayering of inputs in conceiving a project, a process that applies value to them, and teamwork which combines the individual parts into a sophisticated whole. Contributions are to be solicited from every well-chosen team member, especially at a stage where ideas are not fully formed, so that the data received can have the greatest possible impact on the project. For Arup total design was an aspiration: it is 'an ideal which can never – or only rarely – be fully realized in practice, but it is well worth striving for, for artistic wholeness or excellence depends on it, and for our sake we need the stimulation produced by excellence' (Arup 1985a). IPD proves that a portion of Arup's ideals are implementable, though there is still more effort needed to embrace them all.

On the surface, the AIA's IPD calls for a new approach to architecture and integration. Trust, respect, and project ownership are critical components of this process and work method. The contractor is brought onto the team in the early moments of the project and the antagonistic relationship between the architect and contractor is removed by the project structure. The owner or owner's representative is involved more heavily in both the decision-making process and the defining of building goals. All three entities establish the project aims and are intended with this format to work jointly to see that they are met. In addition, financial incentives are shared by all. This delivery system is about improving how the architect, owner, and contractor work together for the betterment of the project. For engineering team members, however, the question remains: what has changed? They are neither included more directly in the project hierarchy nor has their position in the project been re-evaluated in IPD. The case study evaluation brings added depth to this inquiry as it demonstrates what is perceived as important in the application of the process. This is true not only through the choice of projects researched but the factors chosen to be studied. For the selected projects, the structural engineer remains in traditional roles as a consultant or in their position within an A/E firm. Four of the projects did not list structural engineers as part of the team indicating that their role was insignificant to the implementation of the method. When addressed at all, the engineer is criticised. Critiques of the engineer state that consulting engineers have difficulty changing to meet the demands of the new project methodology. There are several reasons why this might occur. Engineers may not be up for the challenge and unwilling to confront how they work themselves. Another view is that engineers are neither equally prepared nor sufficiently incorporated into the process, meaning that the new method provides little value to them. In IPD, there is no thoughtful consideration to how the engineers' skills might be better incorporated; it is an opportunity lost.

The next step in this research might include a detailed study of the engineering participants, their input, and their conclusions of IPD. Perhaps the role of the consulting engineer has expanded, but it was not been caught in the case studies. Or, perhaps IPD has more team members that are to be included. The intent for a greater collaborative experience for all is throughout the IPD guide, but not in its explicit structure. Another round of editing and evaluation is needed to understand and incorporate engineers and their potential into the process. Unmistakably, IPD is a bold new vision for practice. The AIA has moved beyond talking about creating more integrative practice towards trying to institute real change. However, as articulated, it does not enact Arup's visions of a better design environment for more meaningful architecture. Until more of his ideas are incorporated, the role of the engineer remains diminished, thus falling short of the potential for total design.

Note

1. Arup speaks of this on a few occasions. His thoughts on his influence can be seen later in career in his "Institution of Structural Engineers GoldMedal Speech." Reprinted in *Arup Journal* 20 (1): 45–46.

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