Masterbuilder as a Team Interdisciplinary Project Team. An Attempt at Analysis

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„When many cooks make a dish, they have better agree amongst themselves about the recipe" [1]
Ove Arup

It's a striking fact that in a world of highly specialized professions (stimulated by the development of science and technology) as well as precise legal regulations defining rules of standalone practice in building industry, we've lost a single person capable of providing full knowledge necessary for completing building venture, as it was common 100 years ago. It's not a good time for a master builder, we know from middle ages.

The subject of the paper, focuses on the important issue of interdisciplinary cooperation and concerns both architecture and urban planning ventures. A design task, in this sense, should be treated equally as a preparation for the accomplishment of a certain goal [2] i. e. the construction of a building or a city. A design team is composed of representatives of various disciplines. Each of them is important, and the expertise at his or her disposal is necessary for the perfect realization of the design task.

The composition of the team depends on the complexity of the design task. Most often its core is made up of an Urban planner or/ and an Architect and an Engineer, a specialist in the narrow field of knowledge[1].

Each member of the team has specific competencies. They are primarily defined by the disciplines, secondly by the specific nature of the interdependence of disciplines. Personal attributes of team members are also of great importance.

Described differences and resulting interdependencies are the basis for the analysis of the problem of interdisciplinary cooperation presented in the article. The analysis focuses on two formerly undivided fields, architecture and structure. Proposed simplification will allow reducing the problem to two fundamental threads of each project, that is – according to W. Gasparski's definition - the intention and execution of a specific form of architectural work understood only through the prism of its shape and static.

This approach is often present in other studies concerning the problem of interdisciplinary cooperation.

Research on the issues of interdisciplinary cooperation is undertaken in academic centers around the world. It is a broad subject, involving specialists in many fields, including management and psychology. The participants are students for whom this is their first experience of cooperation within a project team working in an artificially created environment. It is worth mentioning, however, that these initiatives involve professionals (practitioners), acting as consultants and reviewers [3], [4],[5] as well as professional organizations and industry representatives [5].

These projects, while only simulating a professional practice, teach students the basic principles of cooperation and open up new opportunities through the experience that is common to many of the analysed papers. Two main benefits of early interdisciplinary cooperation can be identified:

– Extraordinary performance "Collaborative efforts can produce new and original ideas not possible in a uni-disciplinary setting" [3].

– Breaking the boundaries of specialization - each group learns the specifics of thinking, acting, and priorities of another.

This article proposes to extend the spectrum of the analysed material with the experience of outstanding representatives of design practice. Such a look may confront the effects of research carried out in an academic environment with practice performed in real conditions.

Presented study cannot of course provide a fully objective picture, due to its great diversity. Nevertheless, its attractiveness lies in the fact that, unlike simulations in the academic environment, it depicts the experiences of the most outstanding architects and structural engineers when confronted with above-average problems that place the highest demands on interdisciplinary cooperation. A unique place on this list is occupied by the practice of Ove Arup.

„They really do have a responsibility for putting things together (…) – in the era of specialization – the architect is really all we have whose business is for everything" [6] [7].
Richard Buckminster Fuller

ARCHITECTURE vs STRUCTURAL ENGINEERING. PROBLEM OBSERVED

This is not a good time for the masterbuilder we know from history. Architects as proud successors to these self-sufficient masters of the Middle Ages, are no longer able, like their predecessors, to guarantee such a high quality of service in their profession, i.e. to provide a complete body of knowledge and skills to complete a building venture. The 19th century, with its significant discoveries in the field of construction science and technology, substantially changed the rules of the game.

The consequence of the increase in complications in the construction industry was specialisation, i.e. the increasing fragmentation of knowledge.

[1] The architect is sometimes privileged in this group. Being the chief designer, he can determine the team' s composition. However, this is not the norm. It happens that the investor recommends or imposes the participation of a specialist or specialists. It is most common in the case of large, institutional entities (developers), which want to ensure greater control over the project process.

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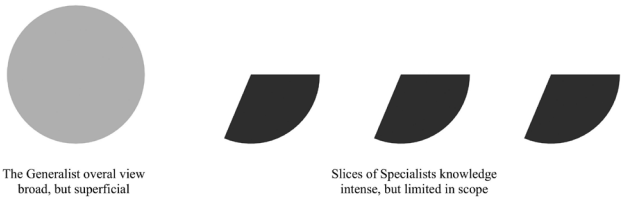

Fig. 1. Diagram showing the generalist and the specialists fields of knowledge

The symmetry of ignorance, as a consequence of specialization, described by Horst Rittel in 1972 [8], is a phenomenon that is common in all types of design ventures requiring the cooperation of representatives of various disciplines. Cooperation is necessary to achieve the goal because none of the parties involved in the project is able to achieve it on their own.

Rittel's work, apart from defining the necessity of collaboration, is characterized in great detail by the specificity of conflicts that may occur during its course. Their cause lies in a different perception of the design problems, which can be both simple (tame problems) and complex (wicked problems). (In the project practice this different perception may be determined by the specialisation and system of education that is specific to it. Architects and engineers may perceive design problems differently.) Tame problems are distinguished by the fact that their solutions can only be correct or false. There is no place for nuances. The solution of a wicked problem, standing in opposition to "tame problem", can only be evaluated as good or bad. Unfortunately "what is good for A is not at all good for B. This is the fate of all solutions to wicked problems: there is no criterion system, nor rule which would tell you what is correct or false"[2]. However, continuous striving for perfection has its price. Wicked problems do not take time into account. There is no stopping rule for them. "You can always try to do better and there is nothing in the nature of the problem which could stop you. You stop for any planning problem because you have run out of time, money or patience"[3]

Rittel's theory of design problems is a perfect illustration of the obvious difficulties in communication between the two disciplines. It is the engineers in the environment who are seen as "solid", while architects, as their opposite, are those undecided artists, constantly looking for a better solution. This obvious simplification can be explained by some specific features of both disciplines.

Architecture is built on a very broad knowledge, which is difficult to explicitly close put within the frames of one discipline. Structural engineering, unlike architecture, is a very precise discipline. Behind it stands a science that defines its competences, creates rigid frames in which a specialist can move, clarifies judgments[4] [9]. The uniqueness of the architecture, on the other hand, is the knowledge that can be interpreted very subjectively, and judgments depend on many factors. If architecture refers to some hard data, it usually comes from another discipline. Mario Salvadori gave a great impression of that difference "Architects, psychologically and by disposition and training, are generalists, among the last humanist left in our technological culture. They must know more and more about everything and end by knowing very little about everything. On the other hand the engineer typically is a specialist in particular branch of engineering, and consequently knows everything about very little" [10] Surrounded by specialists, the architect is a generalist. His knowledge, although extensive but superficial, enables him to communicate with the team. Referring to Rittel's observation, however, he does not have the ability to solve problems on his own. Communication between the generalist and the specialist can be cumbersome. The architect, and this is a certain weakness of his/her discipline, may be jealous of the engineer's ability to argue precisely. There is a whole arsenal of reasons on the part of an engineer, which is undoubtedly due to his specialist knowledge, with which it is difficult for an architect to discuss. This is a certain inequality in the generalist's relationship with a specialist.

Knowing the role that each designer plays as part of the team can be the key to successful collaboration. This participation cannot be limited only to narrow competences defined by the boundaries of specialisation. The need for a holistic understanding of the problem is fundamental in this case. This is part of the knowledge that students (Jurevic) acquire during the workshops, it is also the experience of outstanding practitioners, including Ove Arup.

The concept of Ove Arup cooperation is a unique example of the 20th-century practice. (only the SOM Chicago under the leadership of architect Bruce Graham and structural engineer Fazlur R. Khan in 1960-1980 can compete with it in terms of theoretical background and practical achievements). The uniqueness of Arup's approach is based on his universal inspirations, including both physical as well as ideological spheres.

„The word architecture somehow suggests a concern about the brief, about what we should build, about function an delight, whereas „engineering" suggests efficiency in fulfilling the brief. Both are needed, for whatever we build."

Ove Arup [11]

MASTER BUILDER AS A TEAM. OVE ARUP

"Composite mind"[5] is Ove Arup's idealistic vision of an almost symbiotic collaboration of an interdisciplinary project team. This symbiosis can be seen, with a certain degree of deliberate exaggeration, as an opportunity to recreate the "master builder" concept, which materializes not in one outstanding person but in a group of competent professionals.

The vision of Ove Arup, although idealistic, was a successful effort to combine the ambitions and aspirations of architects and engineers of the first half of the 20th century, the fruits of the industrial revolution with the modernist desire to renew architecture, architecture that is closer to man. The Arup team's achievements are probably the first so spectacular example of cooperation between an Architect and an Engineer, implemented in a consistent way (total design). The awareness of the value of working in a team, but also of the role and various competences played by architects and engineers in it, is reflected in the content of his speeches and publications[6] [12]. It is a very precisely defined ethic of teamwork. According to this ethic, both architects and engineers have special responsibilities towards society and the environment.

„The first condition is that all members of the team subscribe to the aim, that they want to help to produce good architecture, architecture in-depth (…) as well as efficient function end economy (…) To me, it is surprising that so many people have no difficulty in ignoring the fact which stares us in the face, and which has been stressed by poets, saints, and thinkers throughout the ages, that what has most value for man cannot be measured, bought or obtained by force, but must be given freely. And that whether our manmade environment pleases us or not , depends on unmeasurable qualities which can only be created by artistic inspiration and creation" [11] (…).

Architects and engineers have equal responsibility for what they do. It is a remarkable testimony to humanism, to the understanding of values that go far beyond the standard frames of each discipline they represent. *"All the members have to forget part of their training and acquire new understanding and skills. Barriers – which are astoundingly so-*

[2] p. 392 [8].
[3] p. 392 [8].
[4] Peter Rice commented this „fate" of the structural engineer in his book „in the minds of the public and of other professionals, the engineer is associated with unimaginative dull solutions. If people find an engineer making original designs, designs which only an engineer can make, they feel the need to grant him or her a higher accolade, hence „architect-engineer".
[5] pp. 2-10 [11].
[6] A large part of the Ove Arup's writings were collected in a monograph celebrating his 90th birthday; the ARUP Journal (March,1985) Arup's legacy is also present in the practice and publications of his outstanding students and collaborators such as Peter Rice, Edmund Happold, Jack Zunz.

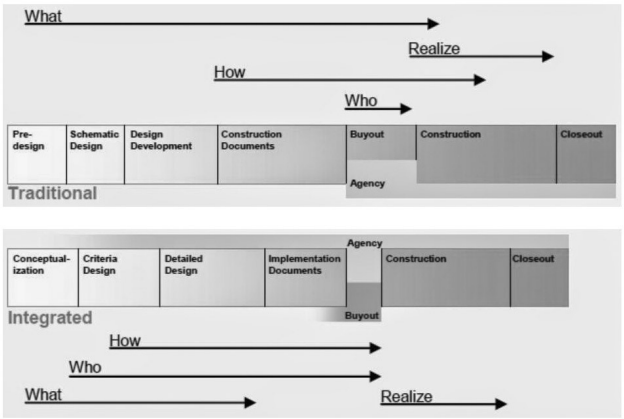

Fig. 2. Traditional vs Integrated workflow according to Integrated Project Delivery Standard [13]

lid and high – must be broken down"[7]*. The postulate "to look beyond the narrow confines of our metier"*[8] means a broad outlook, a conviction that both my and each of the other disciplines have something important to offer. It means respect for the person as well as for the profession he or she represents. Arup did not see in methods the condition of good cooperation, but in people, their attitude towards work and each other. Motivation and mutual respect are, of course, very vague concepts. They define personality traits that can only be developed through appropriate education. But respect, in the context of interdisciplinary cooperation, means more than just an appropriate attitude towards the other person. Respect for the other discipline means believing that its contribution to the realization of the project task is valuable and worthy of the highest attention. With a respect for the discipline of structural engineering, the architect may expect a serious enhancement of his or her work. Instead of late asking for "making this buildable" close and early collaboration with the structural engineer will help make the form of the building unified with the structure, eventually reaching the state of the art solution. In return the structural engineer can get a field of broad creativity not limited by the constraints of "finished concept". Both are opened for ideas and support themselves. Respect for the other discipline also means being aware of the limitations of one's own discipline – a condition that stems directly from the symmetry of ignorance – and consequently becoming open to the opinions of another, which is the foundation of cooperation. Respect for the other discipline opens the discussion, reduces the number of decisions taken a priori, does not force favorable solutions for only one of the parties Such an attitude opens a wide field for creative cooperation of the whole team.

"in integrated project, owner, architect, consultants (…) understand the value of collaboration and are committed to working as a team in the best interest of the project"
Integrated Project Delivery „A Working Definition" [13]

IN SEARCH FOR A BETTER SOLUTION

It is difficult to attribute to collaboration, as Arup sees it in his writings, any precise formula that would impose some predefined structure on it. It is more like a certain concept, or a vision, which can be reduced to a few fundamental conditions.

– The collaboration is launched already at the concept phase. The aim of this is to eliminate solutions that would impose a framework into which the other parties must fit;

– Parties are conscious of their competences resulting from the nature of the specialisation they represent. Their contribution enhances the value of work, a common achievement;

– However, their contribution should not be limited to a rigid framework of specialisation. The fundamental requirement then is a holistic view of the design issue, understanding that each proposal of one specialisation can essentially influence (limit or stimulate) other specialisations and, consequently, the result of teamwork - completed design.

Interestingly, a similar approach can be seen in scientific research papers. They focus on the analysis of case studies – student's workshops. What makes them more structured, are individually defined scenarios, which determines the framework of cooperation, schedule of meetings, consultations with experts, selection, and use of tools [14]. During the workshops, each of the participants taught "other people" to get to know their abilities, a hierarchy was naturally formed (people with a strong personality showed more initiative), certain ways of behavior (extraverted, introverted) resulting from belonging to different cultural circles could be interesting experiences. This illustrates the importance of appropriate composition of the team, where competence must be supported by appropriate personality traits.

An intriguing, in this respect, approach, aimed at defining a model of collaboration, was the IPD (Integrated Project Delivery) standard created in 2007 by the American Institute of Architects. It was an extremely ambitious project whose authors set themselves the goal of changing the traditional model of building ventures known as design-bid-build. This term means a cascading model of cooperation, where the rigid division into phases of realization fundamentally affects the organization of the team (client, designer, contractor). The problem is the limited access to information, e.g. the contractor company does not take an active part in the design process since it is selected only as a result of a tender on the basis of a finished project. The creators of the IPD standard propose a different way of work organisation. Fully integrated process, which from the early design phase includes all parties involved in the venture [13].

IPD, however, is a very difficult solution to adapt, due to the fact that it is so absolute in its assumptions. Apart from designers, contractors, technical advisors(the industry in the broadest sense of the term), must also participate in a design phase. To some extent, it is an ideal vision. Throughout the design process, practitioners - those who will execute the project – as its co-creators, are allowed to share their opinion.

Arup's concept was more flexible. Probably the most famous and spectacular project his office was involved in, the Sydney Opera House, was selected in an architectural competition, and Arup's office joined the team as a structural engineering consultant only after it was settled. Collaboration with an experienced engineering office was, in the opinion of the members of the jury, an important condition for the success of the project, which was mentioned in the sentence: „that a candidate who showed exceptional promise would be able to learn from all the professional advice to which he would now have accesshe would have to grow int the task, but he was trusted to be up to the job" [15] Ove Arup, whose office was finally recommended to Joern Utzon, the author of the winning concept, following the announcement of the competition results, wrote an enthusiastic letter to him: „My congratulations on winning the First Prize! I am very pleased that it was a Dane who won it, and after having seen a sketch of your project, I am ever more pleased – and also somewhat surprised – that such an imaginative, but unusual design has actually been chosen to build, instead of merely being praised, as is mostly the case (…) As far as I can see, it will not be so easy to calculate and detail your design so that your idea is realized in the fullest sense, and for it still to be economically viable (…) I think, however, that you will surmount all the difficulties and create a building which will be of great liberating importance to today's architecture"[9]. Indeed, a great example of understanding and true passion

[7] p. 9 [11].
[8] p. 10 [11].
[9] p. 175 [15].

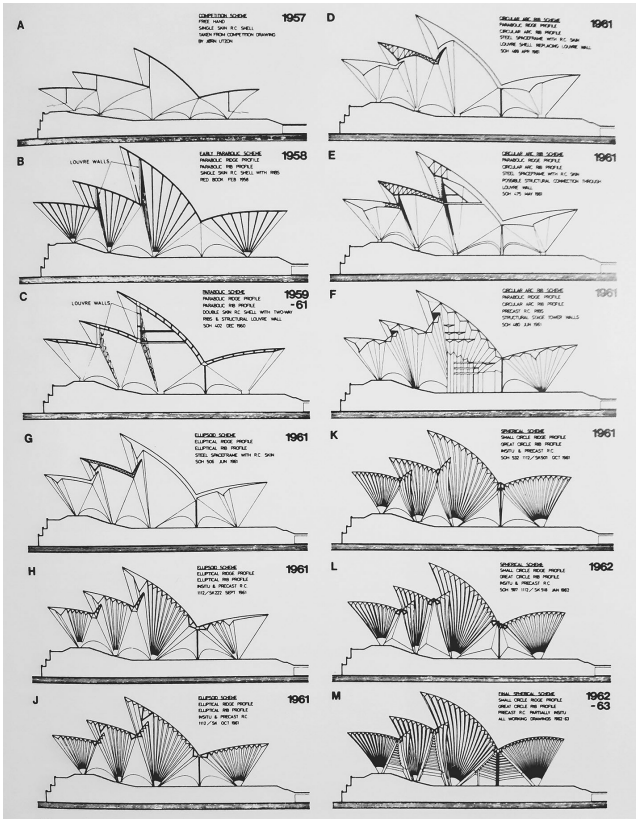

Fig. 3. Evolution of the geometry and structure of the shells for the Sydney Opera House [15]

which united these two outstanding artists.

The project was erected in a shape almost identical to its original concept. However, the structure of white shells over the concert halls had to be changed. On this occasion, the contribution of Ove Arup's office was reduced to formulating a method that allowed for the execution of the form dictated by the architect. But this method, extremely imaginative on its own, was a proof of understanding of the role engineer plays in cooperation with the architect, while the continuous pursuit of its best, most appropriate version, his acceptance of the complex nature of design problems. One can find an expression of that approach in Arup's own words "Engineering problems are under-defined, there are many solutions, good, bad and indifferent. The art is to arrive at a good solution. This is a creative activity, involving imagination, intuition and deliberate choice" [16].

Interestingly enough, the Sydney Opera House example also demonstrates Arup's unique approach towards collaboration as such. Under his wings the careers of excellent professionals have developed, among them Jack Zunz, Peter Rice, and Edmund "Ted" Happold. A fully democratic style of management, where challenges, responsibility, and appreciation are shared by the team, rather than individuals, is also present in the legacy of his best pupils.

"More deliberation does not lead to agreement, thought it may lead to understanding; one cannot enforce agreement, but the likelihood of agreement and the effect of learning from each other is greater"
Horst Rittel [8]

CONCLUSION

The aim of the interdisciplinary project team is to achieve the best possible realization of the project task. The symmetry of ignorance can become symmetry of knowledge, where "Collaborative efforts can produce new and original ideas not possible in a uni-disciplinary setting" [3] - this positive view of specialization is possible thanks to proper cooperation of the team. The specific nature of the disciplines represented by the team members distinguishes two basic categories of them: generalist (architect, urban planner) and specialist (engineer). Each should be equipped with two types of competences: knowledge competence defined by the discipline (specialization) and teamwork competence specific only for its category:

– The architect, as generalist, should be equipped with a special privilege, which makes his function unique and is extremely valuable for team communication. The ability to cover the complete issue. This ability allows him or her to control the creative process of the team, define goals, and verify the results. Generalizing, therefore, basically consists of two basic functions: general knowledge of the broadest possible spectrum of building knowledge and a comprehensive view of the design task. These functions can be called basic architect's competences, which determine effective communication in the design team.

Almost every decision made by an architect requires verification based on hard data obtained from the engineer (specialist), therefore

– The engineer's competence is to develop the design task thro-

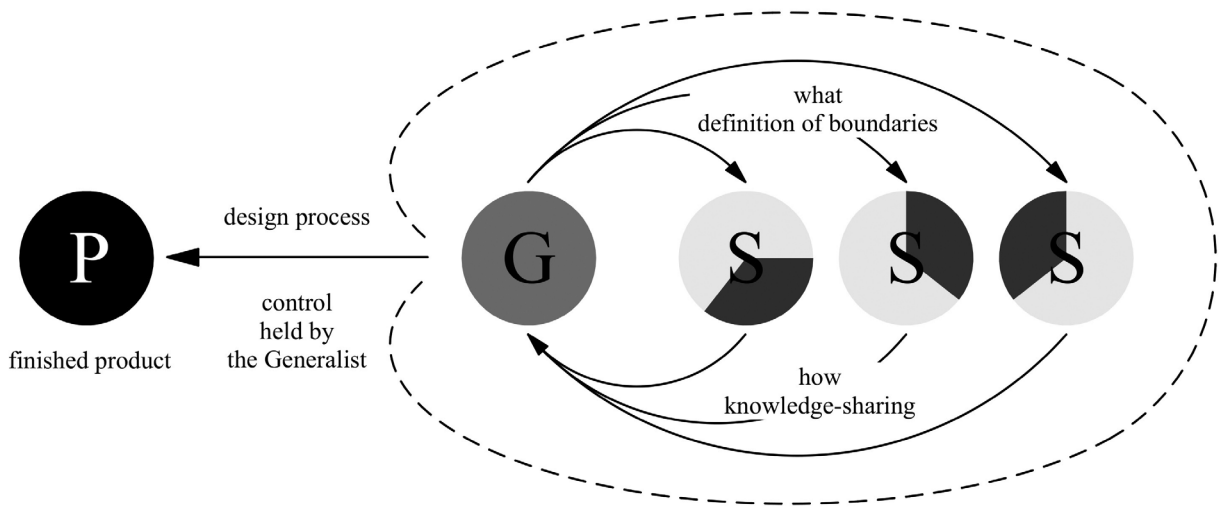

Fig. 4. A design process involving entities with clearly defined functions and competencies. Exchange of information between the generalist and the specialist carried in constantly recurring processes of the definition of boundaries and knowledge-sharing. Control of the design process is the competence of the generalist. The result of cooperation conducted this way is a finished product (chair, building, city).

ugh specialist knowledge. In other words, defining the way the project can be executed. What is crucial, however, is for the engineer to understand his or her contribution in a creative way. Since every project problem is a wicked problem.

The division into specialisations, for a team equipped with such competences, is a value, not a problem. A generalist and a specialist are an essential part of it. Aware of their dependence, they form a relationship in which the creativity of an architect is supported by the innovation of an engineer[10]. A true "composite mind".

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DOI: 10.5604/01.3001.0014.2091

CORRECT METHOD OF QUOTATION
Bujak Piotr, 2020, Masterbuilder as a Team. Interdisciplinary Project Team. An Attempt at Analysis, „Builder" 07 (276). DOI: 10.5604/01.3001.0014.2091

Abstract: It's a striking fact that in a world of highly specialized professions (stimulated by the development of science and technology) as well as precise legal regulations defining rules of standalone practice in building industry, we've lost a single person capable of providing full knowledge necessary for completing building venture, as it was common 100 years ago.

It's not a good time for a master builder, we know from middle ages.

Every planning venture, whether its purpose is to create a chair or a city, requires appropriate preparations. What distinguishes these two extreme examples, in particular, is the scope of knowledge necessary for their execution. While a chair is a relatively simple task to complete, it can be planned and executed by a single person, a contemporary building or a city requires the cooperation of various specialists.

Interdisciplinary cooperation, although sometimes perceived as a problem and an unpleasant necessity, can be an opportunity for a unique work outcome.

The article is an attempt of analysis of this complex problem, which by reviewing selected reference material - including both scientific studies and testimonials of outstanding practitioners - introduces its concise characteristics, problems, and advantages, but, most importantly, tries to define the conditions required for successful collaboration.

Keywords: interdisciplinary team, cooperation, architect, structural engineer

Streszczenie: ZESPÓŁ JAKO MISTRZ BUDOWLANY. INTERDYSCYPLINARNY ZESPÓŁ PROJEKTOWY. WSTĘP DO ANALIZY. Artykuł jest próbą analizy zagadnienia współpracy międzybranżowej. Zakres analizy dotyczy dyscyplin architektury i konstrukcji. Materiał źródłowy wykorzystany do analizy obejmuje zarówno wybrane publikacje przedstawiające rezultaty badań przeprowadzonych w ośrodkach akademickich, jak i świadectwa wybitnych przedstawicieli praktyki projektowej, ze szczególnym uwzględnieniem dokonań Ove Arupa.

Zaproponowany dobór źródeł pozwala na porównanie doświadczeń o charakterze eksperymentalnym w sztucznie wykreowanym środowisku (doświadczenia akademickie), z praktyką realizowaną w rzeczywistych warunkach. W artykule wyróżniono i scharakteryzowano wybrane problemy w komunikacji między analizowanymi dyscyplinami.

W konkluzji wyszczególniono dwie główne kategorie dyscyplin kształtujących zespół międzybranżowy: „generalistyczną" (architekt, urbanista) i specjalistyczną (inżynier), oraz charakterystyczny dla nich zestaw kompetencji. Zaproponowany podział ma na celu opisanie podstawowych funkcji członków zespołu międzybranżowego jako gwaranta prawidłowo realizowanej komunikacji.

Słowa kluczowe: zespół interdyscyplinarny, współpraca, architekt, inżynier

10 These words relates to the thought of Peter Rice describing his view of the architect and the engineer roles in the design process „The architect, like the artist, is motivated by personal considerations whereas the engineer is essentially seeking to transform the problem into one where the essential properties of structure, material or some other impersonal element are being expressed. This distinction between creation and invention is the key to understanding the difference between the engineer and the architect, and how they can both work on the same project but contribute in a different way"[9]