

Figure 1. The chart showing how the effort and cost of the design changes are affected as the project progresses (Anon.)

Simulation tools are a key contributor to this shift because they allow designers to gain insight into how their building will perform with different specifications and to choose the optimum design. By putting analysis tools into the hands of architects and by utilising building analysis from the very first stages in a building's design, designers can make informed decisions over the best strategy and optimise the buildings performance. To build such a simulation tool, we need to understand the thought process of an Architect and what all parameters go into the decision making of the design in its early phase. For this reason a study was conducted to identify the specifications that go into the thought process of an Architect that helps them in the decision making at an early stage. This survey also helped in recognizing the potential user group who are ready to test the tool in its development stages and provide us with their feedback. The intent is that, by involving the architects in the process of development of an early design tool one can ensure the user friendliness of the tool and also encourage the architects to use the tool in their design process.

RESEARCH METHODOLOGY

In an attempt to understand the user's needs on a larger scale we conducted a survey among the architects from all over India to investigate their existing practice, needs and expectations from a design tool to be used at an early design stage. A survey research method using an online survey form was considered suitable for gathering quantitative and qualitative data from a large number of architects/practitioners. The survey was targeted at architects from all over the country, which includes:

- Senior Architects (10+ years of experience)
- Mid-level Architects (5-10 years of experience)
- Jr Architects (1-5years experience)

An online survey was developed to get information about the early design process of professionals who are involved with architectural design in India. The survey was hosted using an online survey tool, the ‘surveymonkey’ from June 2014 until August 2014. The survey received responses from 100 architects from various cities from all over India. Features from each category surveyed can benefit the proposition of simulation tools that are being developed to support architectural design.

Survey design

The survey consists of 32 questions that are either yes/no questions, multiple choice or the ratings that are weighted on a scale of 1 to 5. Details of the sections are below:

Sample identification - General information about background, professional experience and percentage of commercial projects handled by their firm

- Part A: Design criteria and sequence - Information about the importance of various design decisions for architects and the sequence of design which explains the order in which specific design decisions are taken.
- Part B: This section has 3 parts
 - Part B-1: Enquires if architects feel the need of a quantitative approach for design and if they use energy modelling in their firm.
 - Part B-2: This section populates for the users of energy modelling in their firm. This section enquires about the energy modelling tools they use in their design practice, their feedback on the existing tools and their preference for the future tools.
 - Part B-3: This section populates for the non-users of energy modelling in their firm. This section inquires about the reasons for not adopting energy modelling into their design process
- Part C: This section inquires about the usage of various building materials in their projects and the frequency of their use. The responses will help in developing a database for the early design tool.

SURVEY RESULTS

Analysis of general information

The sample of 100 design professionals who answered the survey is fairly diversified in terms of background (location and climate familiarity). Out of the 100 architects who responded to the survey, 21% are young architects with 1-5yrs of professional experience, 17% are intermediate architects with 5-10yrs of experience and 62% are experienced architects with 10+ years of professional experience. Most of the architects who responded to the survey are non-commercial architects with 34% of them that handle less than 5% commercial projects and 29% that handle 5% - 20% of commercial projects. About 18% of the respondents handle 20% -50% of commercial projects and about 19% of them handle commercial projects above 50%. It is noteworthy that most commercial projects are handled by few big firms in India.

Design process of Architects

The first section of the survey inquired architects about their early design process and the importance they give to various design factors and the sequence of design. Out of 100 design professionals, 80 responded to all the questions in this section of the survey and 20 of them skipped the questions. When questioned about the sequence of their design process, majority of the architects said that they first do zoning of spaces based on the function of buildings (53%), followed by building massing and orientation (45%), followed by assessing the building structure and designing the building elevation. Once all this is decided, they choose the building materials followed by external finish. It is interesting to note that the decision about the building materials to be used for construction is decided at a much later stage, which means that the physical attributes and the material properties do not play a major role in their early design process. When asked if Floor Space Index (FSI) was a dominant issue in their design, 68% of the architects said it was a dominant issue and 32% answered that maximising their FSI wasn't a dominant issue for them in their design. Most of the architects who work on commercial buildings responded that they try to maximise their FSI.

When asked to rank the importance of some design aspects on a scale of 1-5 ranging from 1 being least important to 5 being the most important, 46% said that the cost of the building construction was most important factor for their design followed by energy efficiency (45%) and durability of the building (33%). These design factors are followed by operating and maintenance cost (26%) and building elevation (20%). It can be inferred from the response that though energy efficiency is an important criteria to make design decisions, the design is ruled majorly by the cost of the design decision. From this it is understood that an early design tool should facilitate the architect with results not only in terms of energy consumption/savings but also in terms of cost of construction/savings. Considering aesthetics as the primary objective, 53% said that orientation was the most important decision they make, followed by massing of the building (39%). After these choices the shading (23%) received the higher rating followed by the window size (16%). When inquired about their design sequence with aesthetics as their primary objective, 65% said they would decide the orientation first, followed by massing (28%), shading (5%) and window sizing (3%).

Energy performance of the building being the core focus, architects were asked to rate the design decision on a scale of 1 to 5 where 1 was least important and 5 was most important. The group of design decisions rated as most important by most of the architects are orientation (64%), thermal comfort through natural ventilation (48%) and availability of daylight (44%). These are followed by roof properties (36%), glazing properties (35%), shading (31%), window size (29%) and wall properties (28%). Only 24% of architects said that massing was high priority and 18% said that thermal comfort through mechanical ventilation was a high priority. It was interesting

to observe that architects don't think that building massing is as much of an important design decision that would impact the energy consumption of the building as the rest of the aspects.

Energy modelling in the design process

When inquired if there is a need for more quantitative approach for decision-making with reference to certain design aspects, majority of the architects responded yes to all the design aspects. The design aspects along with the percentage of architects that said that they would need a quantitative approach for taking better decisions are building energy efficiency (90%), water efficiency (89%), building maintenance cost (87%), building initial cost (86%), embodied energy of building material (79%) and building structural stability (76%). When inquired if the architects use energy modelling tools in their office, 34% architects responded that they use them and 68% responded that they won't. Though majority of the architects responded that they think a quantitative approach is required to take design decisions, it is interesting to note that only a third of the respondents use simulation software in their design process. This is an indication that architects can be encouraged to use energy modelling in their early design process by providing them with the right tool.

A set of questions pertaining to energy modelling tools were asked to the 34% of the respondents who responded that they use energy modelling in their design firms. Out of them, 24% use only free software, 24% use only paid software and 52% use both paid and free software for energy modelling in their design process. The software that are most used by these architects are shown in the figure 2

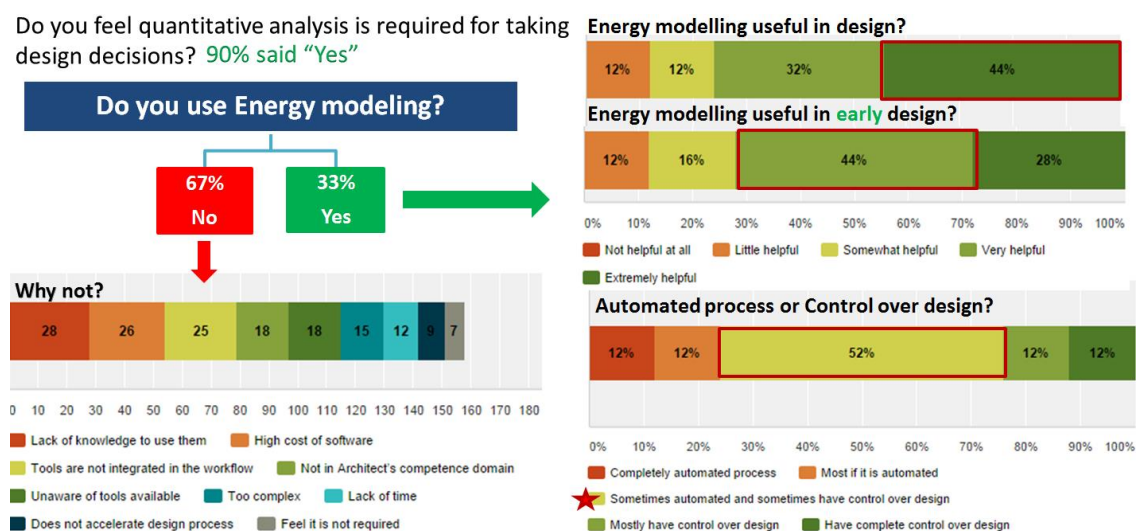


Figure 2. Architects' response to need of quantitative analysis for design and usage of energy modelling tools by architects. Response about the helpfulness of the tools by those who use them and the reasons for not using them by those who don't.

The most popular tools among architects in India are eQUEST (64%), Ecotect (56%) and Visual DOE (52%). The next set of tools popular among architects is EnergyPlus (32%), Radiance (20%), DesignBuilder (20%), IES (12%) and DAYSIM (12%). The set of simulation tools that are used by very few architects are OpenStudio (4%), Energy 10 (4%), Simergy (4%), TAS (4%), TRNSYS (4%) and Green Building Studio (4%). It was interesting to note that one particular architect developed his own tool to suit his design process.

All the architects who use energy modelling tools in their design process find them atleast somewhat useful. 44% of the architects find the tools extremely useful, 32% find it mostly useful and 12% find it somewhat useful. Similarly, out of the architects who use energy modelling tools in their early design process 28% find the tools extremely useful, 44% find it mostly useful and 16% find it somewhat useful. It was observed that a few architects who felt that energy modelling tools are extremely useful in the design process, later responded that the tools are very helpful (instead of extremely help) in the early design process. One can infer that these architects felt that the existing tools do not help as much in the early design stage.

When architects were inquired about their preference for a completely automated process versus having complete control over design, 12% responded that they preferred to have complete control over their design and 12% responded that they would mostly likely prefer to have control over the design. 52% of the architects responded that they would sometimes prefer to have control over design and sometimes want it to be automated. 12% of the architects preferred a completely automated process and 12% preferred that most of the process is automated.

When architects were inquired about the driving factors to use energy modelling tools, 60% of the architects said that they use energy modelling to improve their design quality. Other than improving the design quality the reasons for using energy modelling is for green rating (60%) and professional competence (28%). These are followed by reasons such as the code compliance (28%) and owner's requirement (24%). The importance for selecting an early design tool by architects is in the following order user friendliness (68%), accuracy of results (40%), cost of software (40%), availability of CAD plug-in (36%), extensive library (32%), software support (32%), speed of runs (24%), graphical output (24%).

When inquired about the stage at which energy modelling is used in their design process, 76% answered that they use it at the early design stage while 68% architects answered that they use them at the detailed design stage. 52% of architects use energy modelling for code/rating compliance and 20% architects use it during tender documentation stage. When inquired about the type of improvements they wish to see in the energy modelling software 76% responded that the graphical user interface

should be improved. Next important points are that the software should be free (64%) or have a very minimal cost and that the software should support design iterations (64%). 48% of Architects responded that it should support code compliance apart from being a web-based service (44%).

The reasons for the non-user group for not using energy modelling in their design process are the lack of knowledge to use the energy modelling tools (54%), high cost of the software (50%) and that the existing tools are not integrated into their design process (48%). Some architects responded that they are unaware of the tools (35%) available and that they feel that energy modelling is not in their competence domain (35%). 23% of the architects responded that they do not have time for energy modelling and that 17% of the architects felt that these tools do not help in accelerating the design process. 14% of architects feel that energy modelling is not required for designing a building. From the responses, one can conclude that if the architects are provided with easy to use software that is integrated into their design process which is available for minimal cost, they are encouraged to use energy modelling in their design process.

Construction material usage and their occurrence

The intent of the last section of the survey was to find out the use of various building materials used by the architects in their projects and the frequency of usage. This section was designed to help in the development of the database for the software in line with the construction practices in India. The external walling materials that are used the most by architects in their projects are clay bricks, cast-in situ concrete and fly ash bricks. These are followed by AAC blocks and concrete blocks. Stone masonry is used very rarely or it has been used in the past. The roof material that is used the most is Reinforced Cement Concrete (RCC) followed by timber roof and stone roofs that are both used very rarely.

Most architects use single pane glass windows followed by double pane clear glass, double paned low-e glass windows and double pane reflective glass windows. The window frame materials that are extensively used in the field by architects are in the following order: aluminum, wood, plastic/PVC and steel. The window operation type that is adopted by most architects is casement type followed by slider type and fixed windows. Types of external shading mostly used by architects are horizontal shades, followed by recessed windows and vertical shades. Movable shades are rarely used in the projects by most architects in India. Internal shades are used always by 6% of architects, often by 11% of architects, sometimes by 26% of architects and rarely by 19% of architects in their projects. 32% of architects never use internal shading in their projects. Widely adopted passive strategies by architects are cool roofs, followed by thermal mass and stack effect. Few architects adopt solar chimney in their projects.

CONCLUSION

Energy modelling can enhance substantially the quality of architectural design. However, the use of simulation as part of the architectural conceptual process still comes up against the lack of methods that are in tune with the way architects design their buildings. Therefore this survey was an attempt to find out about the early design process of architects, their construction practices and their preference from a design tool to be used in their early design process. From the survey it was evident that even though majority of the architects think that a quantitative approach is needed for taking better decisions, only a third of the architects use energy modelling tools in their design process. The survey also concluded that given an easy to use energy modelling software that has minimal cost and that which is well integrated into their design process, architects will be encouraged to use energy modelling in their design process. The results of this survey will aid in the development of an early design tool that integrates into the design process of architects and designers.

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