

**AN AFFORDANCE FRAMEWORK TO FORMALIZE
THE INTEGRATED DESIGN OF BUILT
ENVIRONMENT**

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**DEPARTMENT OF CIVIL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY DELHI
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ENVIRONMENT**

by

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DEPARTMENT OF CIVIL ENGINEERING

Submitted

in fulfilment of the requirements of the degree of Doctor of Philosophy

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CERTIFICATE

This is to certify that the thesis entitled “An Affordance Framework to Formalize the Integrated Design of Built Environment”, being submitted by Ms. Durva Gupta to the Indian Institute of Technology Delhi for the award of the degree of Doctor of Philosophy is a bonafide record of the research work carried out by her under my supervision and guidance. The thesis work, in my opinion, has reached the requisite standard, fulfilling the requirements for the degree of Doctor of Philosophy. The contents of this thesis, in full or in parts, have not been submitted to any other University or Institute for the award of any degree or diploma.



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A handwritten signature in blue ink that reads "Durva Gupta". The signature is written in a cursive style with a horizontal line underneath the name.

Durva Gupta

ABSTRACT

The construction industry is making immense efforts in transition from highly criticized fragmented practices to much effective integrated approaches that will result in successful project outcomes. The purpose of shifting towards integrated design (ID) approaches is to bring multiple disciplines and project participants together during the design phase, encouraging collaborative working and exchanging information at the earliest. Although the theoretical capabilities of ID process are well-founded, the effective implementation of integrated working practices remains a challenge. The objective of this research work is to investigate the ID process and propose a framework to streamline the implementation of ID process during conceptual design and planning.

Comprehensive literature reviews, six case studies, expert interviews, and workshops served as the foundation for the research. First, the research work states the existing scenario of the ID process and suggests a preliminary structure for improving it. Then, the research study provides a design theory-based framework to formalize the integrated working of stakeholders during the design phase. The focus of the research study is to understand ‘how’ to implement ID rather than ‘what’ should be done to achieve ID.

Conceptual design is understood as one of the early stages of a construction project, during which informed design decisions are made. In practice, specialists such as architects and engineers lead the design process, which also involves users and project clients as data sources and results in the schematic representation of the building. To build integrated design thinking during conceptual planning, such design processes are modified under the guidance of affordance-based design theory, which is adapted from product design theory. The findings of this research study are synthesized into an Affordance-based framework in which user-designer interaction within the built environment is carefully investigated from project briefing to design phases.

Affordances are a concept similar to functionality, but they depend on the subjective view of users, situation, context, and experience. Affordances are defined by the interaction that occurs between users and designers within a project context. The design development stages of a project were influenced by the knowledge of affordances, inputs from stakeholders’ participation, and project requirements analysis. As a result, the framework merges all interrelated activities during the conceptual phase and provides a visual overview of integrated working practices.

The results of the study describe the affordance-based techniques that contribute to structured design discussions, managing stakeholders' inter-dependencies, satisfying the needs of building users and maximizing the usability of complex buildings. The outcomes from the chosen six case projects demonstrate that integrated design can be carried out in structured steps and that users can have a constructive influence on the prospected architectural environment, provided that the user-designer integration occurs early and is appropriately managed. Moreover, the framework includes affordances as a metric for comparing design alternatives and thus evaluating the project design outcomes. The research study has relevance to both academicians and professionals such as architects, engineers, project managers, and client organizations planning new building facilities, particularly experts working with the integrated design of construction projects.

सार

निर्माण उद्योग अत्यधिक आलोचनात्मक खंडित प्रथाओं से अधिक प्रभावी एकीकृत दृष्टिकोणों में परिवर्तन के लिए अत्यधिक प्रयास कर रहा है जिसके परिणामस्वरूप सफल परियोजना परिणाम प्राप्त होंगे। एकीकृत डिज़ाइन (आईडी) दृष्टिकोण की ओर बढ़ने का उद्देश्य डिज़ाइन चरण के दौरान कई विषयों और परियोजना प्रतिभागियों को एक साथ लाना, सहयोगात्मक कार्य को प्रोत्साहित करना और जल्द से जल्द जानकारी का आदान-प्रदान करना है। यद्यपि आईडी प्रक्रिया की सैद्धांतिक क्षमताएं अच्छी तरह से स्थापित हैं, एकीकृत कार्य प्रथाओं का प्रभावी कार्यान्वयन एक चुनौती बनी हुई है। इस शोध कार्य का उद्देश्य आईडी प्रक्रिया की जांच करना और वैचारिक डिज़ाइन और योजना के दौरान आईडी प्रक्रिया के कार्यान्वयन को सुव्यवस्थित करने के लिए एक रूपरेखा का प्रस्ताव करना है।

व्यापक साहित्य समीक्षा, छह केस अध्ययन, विशेषज्ञ साक्षात्कार और कार्यशालाओं ने शोध की नींव के रूप में कार्य किया। सबसे पहले, शोध कार्य आईडी प्रक्रिया के मौजूदा परिदृश्य को बताता है और इसमें सुधार के लिए प्रारंभिक संरचना का सुझाव देता है। फिर, शोध अध्ययन डिज़ाइन चरण के दौरान हितधारकों के एकीकृत कामकाज को औपचारिक बनाने के लिए एक डिज़ाइन सिद्धांत-आधारित ढांचा प्रदान करता है। शोध अध्ययन का फोकस यह समझना है कि आईडी प्राप्त करने के लिए 'क्या' किया जाना चाहिए, इसके बजाय आईडी को 'कैसे' लागू किया जाए।

वैचारिक डिज़ाइन को एक निर्माण परियोजना के शुरुआती चरणों में से एक के रूप में समझा जाता है, जिसके दौरान सूचित डिज़ाइन निर्णय लिए जाते हैं। व्यवहार में, आर्किटेक्ट और इंजीनियर जैसे विशेषज्ञ डिज़ाइन प्रक्रिया का नेतृत्व करते हैं, जिसमें डेटा स्रोत के रूप में उपयोगकर्ता और प्रोजेक्ट क्लाइंट भी शामिल होते हैं और परिणामस्वरूप इमारत का योजनाबद्ध प्रतिनिधित्व होता है। वैचारिक योजना के दौरान एकीकृत डिज़ाइन सोच का निर्माण करने के लिए, ऐसी डिज़ाइन प्रक्रियाओं को सामर्थ्य-आधारित डिज़ाइन सिद्धांत के मार्गदर्शन में संशोधित किया जाता है, जिसे उत्पाद डिज़ाइन सिद्धांत से अनुकूलित किया जाता है। इस शोध अध्ययन के निष्कर्षों को अफोर्डेस-आधारित ढांचे में संश्लेषित किया गया है जिसमें निर्मित वातावरण के भीतर उपयोगकर्ता-डिज़ाइनर इंटरैक्शन की परियोजना ब्रीफिंग से लेकर डिज़ाइन चरणों तक सावधानीपूर्वक जांच की जाती है।

अफोर्डेस कार्यक्षमता के समान एक अवधारणा है, लेकिन वे उपयोगकर्ताओं, स्थिति, संदर्भ और अनुभव के व्यक्तिपरक दृष्टिकोण पर निर्भर करते हैं। किसी परियोजना के संदर्भ में उपयोगकर्ताओं और डिज़ाइनरों के बीच होने वाली बातचीत से सामर्थ्य को परिभाषित किया जाता है। किसी परियोजना के डिज़ाइन विकास चरण खर्चों के ज्ञान, हितधारकों की भागीदारी से इनपुट और परियोजना आवश्यकताओं

के विश्लेषण से प्रभावित थे। परिणामस्वरूप, रूपरेखा वैचारिक चरण के दौरान सभी परस्पर संबंधित गतिविधियों को विलीन कर देती है और एकीकृत कार्य प्रथाओं का एक दृश्य अवलोकन प्रदान करती है।

अध्ययन के परिणाम व्यय-आधारित तकनीकों का वर्णन करते हैं जो संरचित डिजाइन चर्चाओं, हितधारकों की अंतर-निर्भरता को प्रबंधित करने, भवन उपयोगकर्ताओं की जरूरतों को पूरा करने और जटिल इमारतों की उपयोगिता को अधिकतम करने में योगदान करते हैं। चयनित छह केस परियोजनाओं के परिणाम दर्शाते हैं कि एकीकृत डिजाइन को संरचित चरणों में किया जा सकता है और उपयोगकर्ता संभावित वास्तुशिल्प वातावरण पर रचनात्मक प्रभाव डाल सकते हैं, बशर्ते कि उपयोगकर्ता-डिजाइनर एकीकरण जल्दी हो और उचित रूप से प्रबंधित हो। इसके अलावा, रूपरेखा में डिजाइन विकल्पों की तुलना करने और इस प्रकार परियोजना डिजाइन परिणामों का मूल्यांकन करने के लिए एक मीट्रिक के रूप में खर्च शामिल हैं। शोध अध्ययन शिक्षाविदों और पेशेवरों जैसे आर्किटेक्ट, इंजीनियर, परियोजना प्रबंधक और नए भवन सुविधाओं की योजना बनाने वाले ग्राहक संगठनों, विशेष रूप से निर्माण परियोजनाओं के एकीकृत डिजाइन के साथ काम करने वाले विशेषज्ञों दोनों के लिए प्रासंगिक है।

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ABBREVIATIONS

ID	Integrated Design
IWP	Integrated Working Practices
ABD	Affordance-based Design
ASM	Affordance Structure Matrix
DAU	Designer-Artifact-User
AUA	Artifact-User Affordances
AAA	Artifact-Artifact Affordances
IPO	Input–Process–Output
MEP	Mechanical, Electrical and Plumbing
HVAC	Heating, Ventilation and Air conditioning
BIM	Building Information Modelling
QFD	Quality Function Deployment
AD	Axiomatic Design
MCDM	Multi-Criteria Decision Making