DEVELOPMENT OF BIM HANDBOOK FOR PAKISTAN

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Embarking on this journey of Masters had been a very ambivalent endeavor for myself. But I have absolutely no doubt that the sagacity and understanding this route has imbued me with has made me much a better person than the one that started on it.

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ABSTRACT

Building Information Modeling has the potential for solving most if not all existing problems of the construction industry. Where most developed countries have a thriving BIM infrastructure and developing nations are working diligently towards it, Pakistan is woefully lagging behind. Many countries around the world such as United States of America, Canada, Australia, Finland, Norway, China, Singapore, Malaysia etc. have dedicated publications for the industry to understand the BIM process for subsequent implementation of BIM in their work processes. Whereas, in Pakistan, although the idea of adoption of BIM in construction has been slowly gaining momentum, no set of guidelines or standards of procedure exist to aid in the process. This has also been cited as one of the reasons for slow of BIM. To cater to this specific need, tailored guidelines were developed in the Pakistani perspective. For this purpose information requirements, as deemed necessary for BIM implementation in Pakistan at current stage were identified and validated through expert opinion. Through this foundation of identified aspects, tailored content for each aspect was developed through literature and prevalent industry practices. A document was formed which was again taken to industry professionals for validation and subsequent development of BIM Handbook for Pakistan.

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CHAPTER 1 INTRODUCTION

1.1 Study Background

Chuck Eastman in 197 first coined the term Building Information Modeling, which has been in use under different names for more than two decades now (Ali et al., 2018). BIM has been positively transforming the Architecture, Engineering and Construction (AEC) industry in definitive steps rather than slow gradual changes, aptly termed as the game-changer (Doan et al., 2019). Keeping in line with the advances in technology, many countries such as Australia (NATSPEC, 2016a), New Zealand (Committee, 2019), United Kingdom (EUBIM Task Group, 2016), United States of America (U.S. General Services Administration, 2007), Hong Kong (Department, 2019) and Singapore have adopted BIM as a way forward through policy and provided published guidelines to facilitate the adoption and implementation of BIM, paving way for construction industries around the world. BIM implementation not only saves time and cost but also provides a solid base for future working, cooperation and operation of the constructed facility, saving resources and avoiding uncertainties and unforeseen risks (Eilers et al., 2020). Studies show that the projects carried out through BIM from conceptual to completion stage save approximately 10 to 20% of the time (Migilinskas et al., 2013).

1.2 Problem Statement

Building Information Modeling (BIM) is the word often used synonymously 3D modelling of a building, facility or an infrastructure. While the term BIM remains unchanged, the meaning of the term is often used with matching fervor for an integrated process of information sharing. Chuck Eastman defines BIM as both a process and a product (Eastman et al., 2008). Research has shown rise in use of BIM related software,

especially parametric 3D modeling software(Bui et al., 2016). However, in many of the developing countries the word Revit and BIM are still used interchangeability(Chimhundu, 2015; Gerges et al., 2017a; Sahil, 2016). Lack of awareness of BIM, along with many other reasons identified as the barriers to implementation of BIM, has been a recurring theme identified by many researchers(Gerges et al., 2017b; Hosseini et al., 2016; Latiffi et al., 2016).

Although, extensive and in-depth research and knowledge is available to facilitate, implement and evaluate BIM usage in the industry, research shows that far cry from implementation in true essence, even the adoption of BIM is still in its infantile stage in the developing countries (Olawumi & Chan, 2019). Many developing countries such as Nigeria have sought to cultivate the benefits of BIM into their systems to make the construction process as efficient and less uncertain as possible (Babatunde et al., 2020). However, implementation of BIM requires an in-depth review of the practical processes involving roles of all stakeholders and their interaction, which is not much explored in literature. This leaves a huge gap for exploration on country-level implementation (Sebastian, 2010). Research shows that a strong surge in implementation has occurred in Scandinavian countries including Denmark, Sweden, and Finland, where meticulous guidelines have been formulated for implementation of BIM on multiple levels of organization and projects (Wong et al., 2013). The first edition of BIM New Zealand's BIM Handbook shows that it had a marked positive impact on the implementation of BIM in a more structured manner by a clear definition of roles and responsibilities of stakeholders of construction processes (Davies et al., 2014).

For the case of the Pakistan construction industry, the BIM Implementation is quite low, even the awareness of BIM is a welcome sight (Vighio et al., 2019). A study on BIM awareness in 2020 stated that more than half of its respondents have never

implemented BIM in their work processes (Akdag & Maqsood, 2019). However, another study by Ali. et al (2018) indicated that under a conducive environment of learning through practical application, the inclination towards the implementation of BIM was unanimous among all stakeholders (Ali et al., 2018). This highlights a strong need to develop structured guidelines for BIM adoption and implementation (Masood et al., 2014).

Chuck Eastman authored the first complete handbook on BIM to cater to the need of adoption and implementation of BIM by individuals and organizations (Eastman et al., 2008). This book provided the beacon of hope and a stepping stone towards adoption of BIM worldwide. Following in the example in effectiveness in adoption of BIM through Eastman's book, region specific guides, guidelines, guide books have been published over the years by states, governments, cities and client organizations at local, national and international levels. These guides have paved a complete roadmap identifying and explaining the need for BIM and a complete set of manuscripts meticulously detailing its implementation(Chae & Kang, 2015).

This study aims to develop the guidelines for the AEC industry of Pakistan through incorporation of various BIM implementation areas. This study can benefit major stakeholders of the AEC industry in meeting the targets for the organized BIM implementation.

All public and private projects in Pakistan face issue of Cost and Time overruns. One study performed before and after the execution of a government funded Hospital in Mardan in Khyber Pakhtunkhwah province of Pakistan, highlights the all issues from design to execution phase. The results conclude strongly that the participants of the study and the stakeholders of the Project lean strongly towards BIM after the study

highlighted the issues and their solution in BIM. Participants strongly agree that concessions in both time and cost could have been made with the implementation of BIM at earlier stages (Ali et al., 2018).

This is but one example of the countless issues the study can address by providing an easy solution towards implementation of BIM. Once the end user of the AEC industry has the access to the benefits and knowledge of implementation of BIM, the effect of widespread use of this technology would be monumental towards saving the public and private sector in cost and time.

1.3 Research Objectives:

- To identify the areas on which the various published BIM handbooks have focused and develop the heads of BIM handbook pertaining to Pakistan Construction industry
- Develop the handbook for assisting the adoption and implementation of BIM in Construction Industry of Pakistan

CHAPTER 2 LITERATURE REVIEW

2.1 Study Of BIM Guide Books:

BIM Guidebooks or Handbooks are frameworks used as reference for complete adoption and implementation of BIM (Chae & Kang, 2015).

"A BIM Framework is a theoretical structure explaining and simplifying complex aspects of BIM domain by identifying meaningful concepts and their relationships".

(Succar, 2009)

BIM guidebooks, handbooks, protocols and standards, here after referred to as the BIM books are a collection of frameworks used to effectively employ BIM technology and processes for the better management and execution of construction projects(Kassem et al., 2014). To start the research, as part of the literature review, all existing books were searched on the topic. There are numerous guidebooks detailing the adoption and implementation of BIM. During the course of this research 51 documents matching our mandate were found. Search for these books have been an on-going process of trial and error as not all of these books were titled as such. The main source for collection of these books has been world wide web. Google Scholars and Web of Science were the search engines mainly used to search for these books with key words "BIM Books", "BIM Guidebooks", "BIM Guide" and "BIM Handbook". Further, many of these books had to be searched specifically for a region. Hence, name of a certain country was added to the above key words to find specific books. Some books found were written in the language of their country of origin, hence Google Translator was used to translate these books first before analyzing them.

A concerted effort was put into collecting these books from all continents of the world. Many of these books have been discovered through reference sections of other books or research papers.

After collection of these documents, the documents were numbered and named as per the country of origin. These documents were read and recurring themes were identified. During the research for BIM books, it has been observed that character of the BIM books differs with respect to the general theme and purpose of the book. Some books are focused more towards encouraging the stakeholders to adopt the BIM, hence, only discussing the basic concepts of BIM use along with benefits and opportunities. While some books offer a more advanced approach by going in to the detail as to how BIM can be implemented in a more practical manner, dictating the implementation as per certain set rules and regulations. The phenomenon has also been highlighted by Kassem and Sacks, where he uses the terms *Descriptive* and *Prescriptive* for this (Kassem et al., 2014; Sacks et al., 2016) Hence, in our research the BIM Books area further labeled as per their dominant attribute: Descriptive and/or Implementation Prescriptive as mentioned in table-1.

It is poignant to note that in literature terms "Implementation" and "Adoption" are used interchangeably. For the purpose of our research, these two terms are separated and given distinct meaning that serve this document and research better.

- Adoption: BIM adoption aspect refers to the conceptual aspects of BIM use. It refers to the adoption of BIM science for different stakeholders. These are prescriptive guides.

- Implementation: BIM Implementation refers to implementation of the practical aspects of BIM, concerning more with the details with which different aspects are implemented in field while execution. These are the descriptive protocols.

Further in our research, as per above distinction the guides are further labelled as per their attribute in the table given below (Table-1)

Table 1 BIM Books around the World

Sr. No.	Title	Developed By	Attribute	Country
1	The New Zealand BIM Handbook	BIM Acceleration Committee	Adoption/ Implementation	New Zealand
2	AUS NZ Best BIM Practices (NZIQS)	New Zealand Institute of Quantity Surveyors & Australian Institute of Quantity Surveyors	Implementation	AUS NZ
3	National Guidelines for Digital Modelling	CRC Construction Innovation	Adoption/ Implementation	Australia
4	NATSPEC NATIONAL BIM GUIDE	Construction Information Systems Ltd.	Adoption/ Implementation	Australia
5	CIF BIM Guide Standards and Policies	Construction Industry Federation	Adoption	Ireland
6	AEC BIM Technology Protocol	AEC (UK)	Implementation	UK
7	Little Book of BIM by BSI	BSI.	Adoption	UK
8	Government Soft Landings	UK BIM Framework	Adoption/ Implementation	UK
9	First Steps to BIM Competence	SEC Group, BESA BIM Academy and Build UK	Adoption	UK
10	BIM Protocol	Construction Industry Council	Adoption	UK
11	Singapore BIM Guide	Building and Construction Authority	Implementation	Singapore
12	AEC (CAN) BIM Protocol Canada	CanBIM	Adoption/ Implementation	Canada
13	BIM User Guide for Development and Construction Division	Hong Kong Housing Authority	Implementation	Hong Kong
14	BIM Modelling Manual	Drainage Services Department	Implementation	Hong Kong

Sr. No.	Title	Developed By	Attribute	Country
15	National BIM Guide for Owners	National Institute of Building Sciences	Implementation	USA
16	National BIM Standard	National Institute of Building Sciences BuildingSMART Alliance	Implementation	USA
17	BIM Standards Manual	Dormitory Authority State of New York (DASNY)	Implementation	USA
18	Georgia Tech BIM Requirements & Guidelines for AEC	Georgia Institute of Technology	Implementation	USA
19	GSFIC BIM Guide (Series 1)	Georgia State Financing and Investment Commission	Implementation	USA
20	UoT BIM Project Execution Plan and Standards Guide	University of Tennessee	Implementation	USA
21	College of the Desert	College Of Desert	Implementation	USA
22	BIM Project Execution Planning Guide	Penn state Department of Architectural Engineering	Implementation	USA
23	BIM Planning Guide for Facility Owners	Penn State Computer Integrated Construction	Implementation	USA
24	General Services Administration (GSA) by Chief Architect	US General Services Administration Public Building Service Office of The Chief Architect	Implementation	USA
25	BIM Guidelines and Standards for Architects and Engineers	Division of Facilities Development Department of Administration	Adoption	USA
26	BIM Guidelines and Standards	University of Albany	Adoption	USA
27	BIM Standards and Guides	Florida International university	Implementation	USA
28	BIM project Execution Plan Template For Architects, Engineers and Contractors	University of South Florida	Implementation	USA
29	BIM Guidelines and Standards for Architects Engineers and Contractors	Indiana University	Adoption	USA
30	BIM Standards for Architects Engineers and Contractors	San Diego Community College District	Implementation	USA
31	The VA BIM Guide	Veteran Affairs Office	Implementation	USA
32	BIM Guidelines	University of Southern California	Implementation	USA

Sr. No.	Title	Developed By	Attribute	Country
33	BIM Standards	State of Tennessee Office of the State Architect	Implementation	USA
34	E/A Design Division BIM Standards	The Port Authority of NY & NJ	Adoption/ Implementation	USA
35	BIM Project Delivery Standards	The OHIO State University	Implementation	USA
36	BIM Guidelines and Standards for Architects and Engineers	School Construction Authority	Implementation	USA
37	Guidelines for Vertical and Horizontal Cons	Massachusetts Port Authority	Adoption/ Implementation	USA
38	Norwegian Home Builders BIM User Manual	Norwegian Home Builders' Association	Implementation	Norway
39	EU BIM	EU Task Group	Adoption	Europe
40	The Guide to BIM	ADEB- VBA (Contractor)	Adoption/ Implementation	Belgium
41	Application Guide BIM	CRTI.B	Adoption/ Implementation	Luxembourg
42	BIM by Erasmus+ Programme	Erasmus+	Adoption/ Implementation	Iceland
43	BIM-Guide for Germany	Federal Office for Building and Regional Planning (BBR)	Adoption	Germany
44	Road Map for Digital Design and Construction	Federal Ministry of Transport and Digital Infrastructure	Adoption	Germany
45	BIM Guidelines for Bridges	Finnish Transport Agency	Implementation	Finland
46	Common BIM Requirements	COBIM Project	Implementation	Finland
47	DUBAI BIM Roadmap (Dubai Building Permit Development Committee)	Building Permit Development Committee	Adoption	Dubai
48	BIM Guide by CIDB	Ministry of Works Malaysia	Adoption/ Implementation	Malaysia
49	Charté BIM De La Société Du Grand Paris	Société du Grand Paris	Adoption	France
50	Chinese BIM	Ministry of Housing and Urban Rural Development	Adoption	China
51	Statstyggs BIM Manual 1.2.1	Statsbygg (Norwegian Directorate of Public Construction and Property	Implementation	Norway

In study of these guides different individual characteristics of these books emerge and become more apparent when put in comparison.

During the process of finding above mentioned BIM Books, taxonomy and use of specific terms for different books becomes more and more clear. BIM Handbook, BIM Guide, BIM Protocol and BIM standards have all been used by different agencies issuing these books. These titles hold significance and sometimes define the characteristics of the book itself. BIM uses and the functional characteristics of the books are mainly governed by the issuing body of these books. Still, it is premature to generalize the books as per their originating/ authoring body.

Moving forwards, the astute assessment on identification and division of books by Sacks: Prescriptive and Descriptive, is one of the most effective ways for categorizing these books into different categories(Sacks et al., 2016).

BIM Books with prescriptive nature present more of a persuasive theme, touching in the importance of adoption of BIM to encourage its implementation. EU BIM book is the perfect example and embodiment of this aspect of BIM Books (EUBIM Task Group, 2016). This document is more of a policy document, targeted at European Union members, persuading the use of BIM for the entire continent. The document touches briefly on the importance of BIM in general and tries to cite examples of effectiveness of BIM implementation(EUBIM Task Group, 2016). The Guide for specialist contractors issued in UK does the same job. This document goes deep in explaining the concepts of the BIM and as these relate to the specialist contractors of UK. This book does a very good job at explaining to the contractors the benefits of adoption of BIM into their workings after mandated the use of BIM (BESA et al., 2017). Similarly in USA guide issued by State of Wisconsin, Facilities Development Department of

Administration, on the same line tries to explain different benefits of BIM and also tries to aid the understanding of contractual arrangements needed in adoption of BIM (DFDDA Wisconsin, 2012). Further in the prescriptive arena in project specific category, the guidelines issued by the Société du Grand Paris is a prime example. These guidelines have been specifically built for an infrastructure train track project in the heart of France, Paris, and wishes to use BIM to capitalize on the plethora of benefits offered by BIM, specifically the coordination aspect of BIM (Societe Du Grand Paris, 2017). Around the world authorities have issued same guidelines prescribing the use of BIM in their future projects including Ministry of Housing and Urban Rural Development of China (Ministry of Housing and Urban Rural Development, 2018). Further, guides issued by the Federal Departments in Germany explains very well the adoption procedure of BIM, Employer requirements at different stages of BIM adoption and a look ahead into the future development of BIM (BMVBS Germany, 2013)(Federal Ministry of Transport and Digital Infrastructure Germany, 2015).

On the other side of the spectrum of these books some books have gone into specifics of the implementation of each aspect of BIM. Many such books can be found around the world such as BIM Handbook by New Zealand (BIM Acceleration Committee et al., 2019) National Guidelines for Digital Modeling by Australia(CIC, 2018), BIM Protocols by UK (AEC (UK), 2015) Hong Kong(Hong Kong Housing Authority, 2009), National BIM Guidelines in USA (NBIS BuildSMARTalliance, 2015) etc. Many of these have been published by the Universities and State authorities. Most number of these books have perhaps been published in USA, owing to their 50 states, many of the states have adopted BIM.

One of the prime examples of the descriptive nature of the books is the NATSPEC by Australia (NATSPEC, 2016b) , BIM Guidelines by Veteran Affairs (Department of

Veterans Affairs, 2010), Statsbygg BIM Manual by Norway(Statsbygg, 2013) and COBIM by (Finnish Transport Agency, 2014). These are world class BIM guidelines, touching every aspect of BIM adoption and implementation (Jung & Lee, 2015). These books are an indicator of the progress the BIM has made as these documents have been updated many times as per new emerging requirements and accommodating any change in their national construction guidelines.

These guidebooks give key insight as to current level of adoption of BIM in their respective regions. For example, considering the aspect of interoperability, while the comprehensive guide books from USA such GSA(U.S. General Services Administration, 2007) Veteran Affairs (Department of Veterans Affairs, 2010) Georgia Tech (Applied Professional Services LLC, 2016) etc. emphasize greatly on importance of information exchange and neutral file formats. BIM books by Nordic countries such Finland (Senate Properties, 2012) and Norway (Statsbygg, 2013) specify even the requirement for the use of 2x3 IFC compliant mode. This is indicative of the prevalent use of the BIM technology and advance implementation of BIM in industry.

2.2 Identification Of Heads:

Although, research on BIM adoption and barriers has been conducted throughout the world. Not more than a handful of literature exists on the adoption and implementation of BIM.

Further, the literature already available focuses on developed countries and further advancement of BIM in those areas(Chae & Kang, 2015; Eastman et al., 2008; Tage & Rönndahl, 2018). The literature that exists analyses these BIM books under many constraints. As Sacks and colleagues discuss in their paper, only discussing BIM guidebooks from developed countries that are published in English language. Further

focusing only on developed nations whose industries are atleast at second level of adoption of BIM (Sacks et al., n.d.). Tage and Colleague also use this approach and limiting the number of books to English language only (Tage & Rönndahl, 2018).

In total 51 book were collected from around the world. Hence, these guides were studied one by one. Any new head found pertaining to some aspect not already covered in previous books was also added. Going through each book, tally was kept as to which heads have appeared so far in each book. For this purpose, each guide book was placed in the column, while heads were listed in the rows. If any head was found in a book, then numeral 1 was added in the respective head under their respective BIM Book.

In this research, these books were first studied to identify any recurring theme. It was found that the most of these books follow one of the attributes of Adoption or Implementation, as discussed above, only a few of them follow both. Further, during detailed study of each document, headings explaining different aspects of the books were identified. These heads were further classified as per their use and information provided in each. Some of the heads provided information regarding the introductory aspects of BIM and did not provide much help in the technical / practical implementation of BIM technology. While other went into more detail prescribing execution strategy for each aspect/ function of BIM. At this earlier stage the both the heads and the books were labeled for our own convenience as either having an Adoption or Implementation aspect.

Sr. No.	Attribute	HEADS	NZ BIM - 19	AUS NZ Best BIM Practices (NZIQS) QS Focused	National Guidelines for Didgital Modeling (Aus)	NATSPEC NATIONAL BIM GUIDE (AUS)	Guide Standards and Policies (Construction Industry	AEC (UK) BIM Protocol	Little Book of BIM by BSI	Government Soft Landings (GSL) - by UK BIM Framework	First Steps of BIM Competence (for Contractors)	BIM Protocol (By CIC Built Env. Professions Together)	Sing BIM
			New Zealand	AUS NZ	Australia	Australia	Ireland	UK	UK	UK	UK	UK	Sing
			1	2	3	4	5	6	7	8	9	10	
			AI	I	AI	AI	A	I	A	AI	A	A	
1	A	Analysis & Simulation in BIM	1	1	1	1				1	1	1	
2	A	BIM in {subject Country}	1	1			1						
3		Intro to BIM		1								1	
4		Stages of BIM Adoption		1									
5	A	Benefits/Uses of BIM	1				1			1	1		
6	A	Challenges to BIM			1		1				1		
7	I	Common Data Enviroment	1	1		1		1			1		
8	I	Communication/Collaboration in BIM/CO	1	1	1						1		
9	I	Execution Plan for projects in BIM		1	1	1		1				1	
10	I	Project Brief in BIM				1						1	
11	A	Facilities/Asset Management	1			1							
12	A	Global BIM	1						1				
13	A	Infrastructure/ Horizontal Cons.	1										
14	I	Interoperability			1	1		1					
15	I	IFCs			1	1							
16	I	Information Requirements	1								1	1	
17	A	Consultant Selection	1	1		1		1					
18	A	Contractor Selection	1			1							
19	A	Intellectual Property & Model Disclaimer	1			1							
20	I	Model Planning				1							
21	I	Presentation Style			1	1		1					
22	I	File Naming Convention				1							

Figure 1 Excel Sheet for Heads and their Frequencies

An excel sheet was maintained in order to find the frequency of use of these recurring heads in different books, shown as figure. The alphabets “I” and “A” were placed alongside each book and head marking their defining attribute. Some books were labeled both as IA which means that these books both explain different aspects of BIM while giving detailed instruction regarding implementation.

For each occurrence of head in a BIM guidebook, 1 was placed in the subsequent column. Through this process frequency of occurrence was collected for each head, as shown in Table below.

Table 2 Heads Collected Through Existing BIM Handbooks

Sr. No.	Heads	Frequency
1	Analysis & Simulation in BIM	38
2	BIM in {subject Country}	17
3	Introduction of BIM	22
4	Stages to BIM Adoption	13
5	Benefits/Uses of BIM	24
6	Challenges to BIM	7
7	Common Data Environment	22
8	Communication / Collaboration in BIM/COBie	33
9	Execution Plan for projects in BIM	36
10	Project Brief in BIM	32
11	Facilities/Asset Management	16
12	Global BIM	3
13	Infrastructure/ Horizontal Cons.	4
14	Interoperability	22
15	IFCs	16
16	Information Requirements	33
17	Legal Implications of BIM	8
18	Consultant Selection	5
19	Contractor Selection	10
20	Intellectual Property & Model Disclaimer	14
21	Modelling and Documentation Practices	10
22	Model Planning	26
23	Presentation Style	23
24	File Naming Convention	18
25	LODs	28
26	Coordination in BIM	37
27	BIM Deliverables	29

Sr. No.	Heads	Frequency
28	Combined/Interdisciplinary Models	31
29	Ownership of Models	25
30	Need For BIM	10
31	Opportunities in BIM	10
32	Procurement in BIM	3
33	Contract Types and BIM	14
34	Productivity in BIM	2
35	Project Management in BIM	17
36	Purpose of the Book	26
37	Roles & responsibilities in BIM	38
38	Hardware and Software Requirements	23
39	Security of Data	27
40	Work Flow of BIM	26
41	Detailed appendices for Execution / Implementation	24

Once these heads were finalized, it became apparent that some of these heads were very similar in nature or differed slightly due to the different taxonomy of that region or the authoring body. Hence, these heads that were similar in nature were merged together by similarity analysis under a broader heading that covered both of them. For example, head No. 4 Benefits / Uses of BIM and head No. 5 Opportunities in BIM, in Table-3 given below were merged together under Benefits/ Uses of BIM. After this process of mergence, all heads were accounted for in 31 finalized heads as shown in the Table below. The only head that was not part of this list of "Detail Appendices for Execution / Implementation". This head was is more of an indicator of the level of depth the book goes to in its explaining of the key functions and issues instructions regarding each aspect. Hence, this head was intentionally left out.

Table 3 Finalized Heads After Merging

Sr. No.	Description of Head	Finalized / Merged Heads
1	Introduction of BIM	Introduction to BIM
2	Need For BIM	Need For BIM
3	Global BIM	Global BIM
4	Benefits/Uses of BIM	Benefits/Uses of BIM
5	Opportunities in BIM	
6	Challenges to BIM	Challenges to BIM
7	BIM in {subject Country}	BIM in {subject Country}
8	Purpose of the Book	Purpose of the Book
9	Infrastructure/ Horizontal Cons.	Infrastructure/ Horizontal Cons.
10	Interoperability	Interoperability
11	IFCs	Neutral File Formats (IFCs)
12	Combined/Interdisciplinary Models	Combined/Interdisciplinary Models
13	Common Data Environment	Common Data Enviroment
14	Communication / Collaboration in BIM/COBie	Communication/Collaboration in BIM/COBie
15	Coordination in BIM	
16	Consultant Selection	Contractor/Consultant Selection
17	Contractor Selection	
18	Contract Types and BIM	Contract Types and BIM
19	Stages to BIM Adoption	Stages to BIM Adoption
20	Work Flow of BIM	Work Flow of BIM
21	LODs	LODs
22	Facilities/Asset Management	Facilities/Asset Management
23	Hardware and Software Requirements	Hardware and Software Requirements
24	Project Brief in BIM	Project Brief in BIM
25	Execution Plan for projects in BIM	Execution Plan for projects in BIM
26	Information Requirements	BIM Deliverables
27	BIM Deliverables	
28	File Naming Convention	File Naming Convention
29	Presentation Style	Presentation Style
30	Analysis & Simulation in BIM	Analysis & Simulation in BIM
31	Roles & responsibilities in BIM	Roles & responsibilities in BIM
32	Project Model Management in BIM	Model Planning
33	Productivity in BIM	
34	Model Planning	
35	Ownership of Models	Ownership of Models
36	Security of Data	Security of Data
37	Intellectual Property & Model Disclaimer	

2.3 Validation Through Literature Review:

Research on quality of BIM handbooks and guides remains scarce. However, Rafael Sacks, considered the father of BIM has authored with Chuck Eastman the first ever BIM handbook, a complete guide for introduction, adoption and implementation of BIM worldwide. Rafael Sacks published a paper after conducting in depth study of BIM handbooks around the world. In this paper he outlines the salient features that a BIM handbook or guide should include. Further, another study carried by Isak Tage Karlsson and Christoffer Ronndahl has also worked on the core topics and content of BIM handbooks. In this study they have also studied and finalized 10 BIM handbooks and synthesized essential areas that a BIM handbook or guide should cover.

Hence, for further validation of these heads, the paper published in Journal of ITCon by Sacks and colleagues and the in depth study done by Karlsson was taken as reference for further research work.

Through his above referred research, Rafael Sacks has studied 15 BIM guidebooks and standards published by different organizations. In his research he has identified 10 main heads / topics that have appeared most in the books which are indicative of their importance. Two of these heads were added by writer, which as per writers' expertise are important in the best interest of the procuring agencies i.e., Integrated Project Delivery and Schedule of Payments. As it is expressly stated in the above paper that this research and its findings are based on developed countries with booming BIM infrastructure, these two heads were deemed un-related to the current needs of Pakistani industry which is still in its infancy and in its current state is barely at level 1 of adoption of BIM (Sacks et al., 2016). Similarly, in his study Karlsson has also studied 10 BIM handbooks from around the world. However, in his study Karlsson has only focused on

the National Level BIM handbooks and Guides that are published in English language by the authoring body.

Hence, through the above-mentioned literature a sound criterion has been set for the development of a BIM Handbook. Both of the above-mentioned studies nominate the heads that are essential to any BIM handbook. The heads identified through our research were further validated as they were compared to the heads identified by the published literature. Once our heads were placed under relevant heads identified by the above literature, it was found that most of our heads fall under the criterion set by the literature. Table below shows the comparison below.

The comparison of heads shows that apart from the introductory heads, functional heads mentioned fall under the criterion set by the reviewed literature.

Table 4 Validation Of Heads Through Literature

A review of BIM Protocols, Guides and Standards for Large Construction Clients -Rafael Sacks	**A Study of National BIM Guidelines from around the world determining what future Swedish National BIM Guidelines ought to contain. - Karlsson**	**Head From This Research**
Interoperability	Interoperability	Interoperability
		IFCs
		Combined/Interdisciplinary Models
Modes of Collaboration	Modes of Collaboration	Common Data Environment
		Coordination in BIM
		Communication/Collaboration in BIM/COBie
Pre-qualification of Designers	Pre-qualifications	Consultant Selection
		Contractor Selection
BIM Functions through project phase	BIM Functions through Project Phases	Work Flow of BIM
		Stages to BIM Adoption
		Model Planning
LOD	LOD	LODs
Operation and Maintenance Requirements (COBie)	Operation and Maintenance Requirements	Facilities/Asset Management
		Hardware and Software Requirements
		BIM Deliverables
BIM Execution Plan	BIM Execution Plan	Execution Plan for projects in BIM
		Project Brief in BIM
		Information Requirements
Simulations	Simulations	Analysis & Simulation in BIM
BIM Roles and Responsibilities		Roles & responsibilities in BIM
		Project Model Management in BIM
Schedule of Payments		
	Filing	File Naming Convention
	Archiving	Presentation Style
	Accountability	Contract Types and BIM
		Security of Data
		Intellectual Property & Model Disclaimer

CHAPTER 3 RESEARCH METHODOLOGY

3.1 Introduction:

This chapter describes the methodology for achieving the objectives described in chapter 1. The research design is disclosed first followed by background of data collection and detailed research process including the framework development and its implementation.

3.2 Research Design:

For the first objective of our research, a detailed literature review was been carried out from existing literature addressing the adoption and implementation of BIM and it has been identified that lack of clear guidelines remains a barrier in the adoption of BIM. Then existing BIM guidebooks were studied to identify the heads that are most commonly being used. After collection of heads from the existing BIM books, these heads were further scrutinized through existing research carried out on BIM Books. A preliminary survey will also been carried out among the professionals in Pakistan's construction industry, to further validate these heads as per the country for which they being developed. The survey identified which heads are most relevant to current needs of BIM in Pakistani architectural, engineering and construction industry.

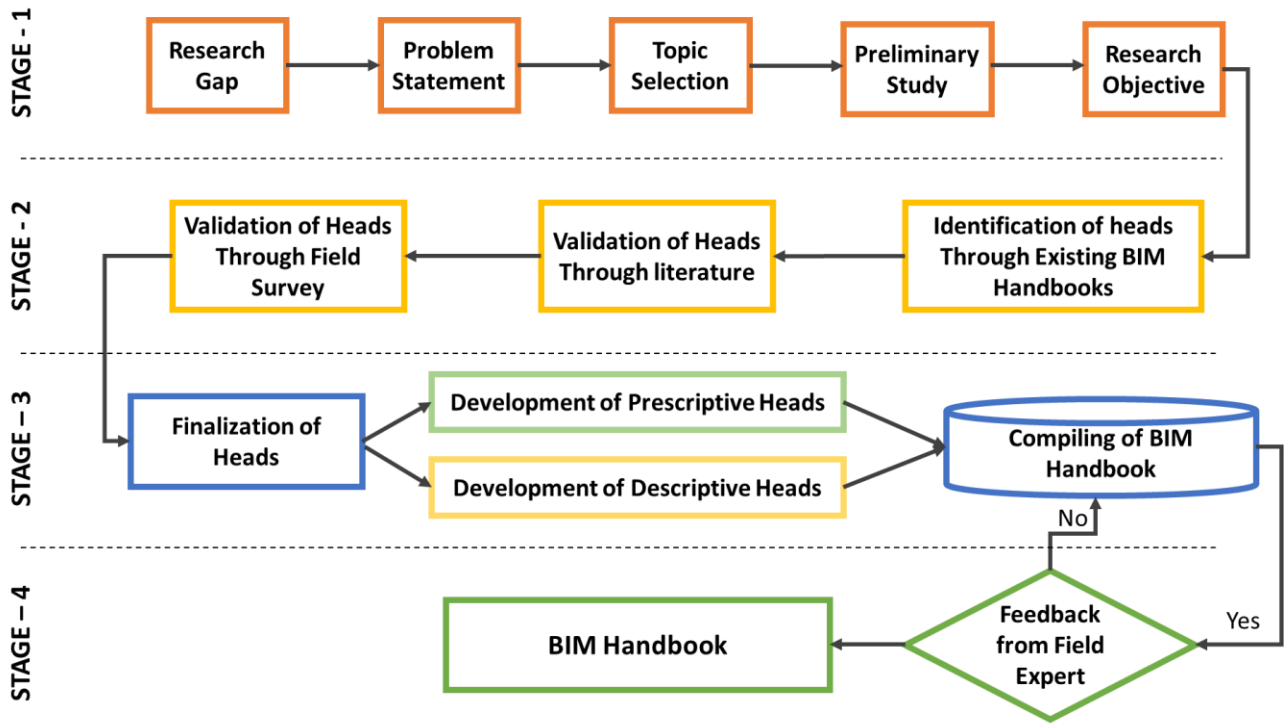

Figure 2 Research Methodology

In order to achieve the second objective, the validated heads would be used as stepping stones towards creation of guidelines specific to Pakistani Industry. These guidelines will be developed through extensive research on existing literature and prevalent industry practices. Each head will be developed by either of the methods of Literature review and industry input, some cases requiring both. Some of the technical aspects may be addressed through existing literature. While aspects relating to adoption as per industry practices would require feedback from industry for which prevalent industry practices would be studied and guidelines would be tailored as per the industry requirement.

After the development of these guidelines, these will be further substantiated by BIM professionals for finalization. Experts in the field of BIM would be approached to shed

light on the developed guidelines to look for any deficiency or addition as per their opinion.

3.3 Field Survey:

After finalization of the heads, relevancy of these to the national needs of Pakistan had to be established. For this purpose, only professionals working with BIM or those professionals who had knowledge of BIM had to be approached. Since the research touches most of the aspects of BIM, the sample size were only the people who understood BIM and its workings and also had some experience working in the architecture, engineering or construction field of Pakistan.

Finalized heads were further formalized in the form of a semi-structured interview on a questionnaire form. The form was formatted after Likert Scale where professionals had to rate the relevancy of each head as per its perceived relative importance for working in Pakistani industry.

The questionnaire was developed through Google forms. It contained two sections, first section pertaining to the introduction of the interviewee. The interviewee were asked about their educational background, years of experience in construction industry, their knowledge of BIM and their experience in BIM. This was done to screen out the people who do not have requisite knowledge of or experience in BIM. In the second part of the interview, interviewee were asked about the importance of the identified heads. Participants were asked to rate the BIM heads as per their importance on a scale of 1 to 5. 1 being the least important and 5 being most important. Explanation or definition regarding each aspect was also given along with each BIM head. This was done to give ready reference regarding each head for better understanding of each head while the

participants rated each head. Section 3.3.1 of this documents contain these heads and their relevant explanation or definition.

Interviewees were contacted through reference and LinkedIn. After, they were briefed about the Interview form which was made in Google Forms. If they agreed to participate, they were sent the questionnaire form and briefed about the aspects of the BIM mentioned in the form, in case there was any confusion in understanding the terms. Hence, the interviewees were asked to rate each aspect one by one.

Since Pakistani industry is still in its nascency, sample size of 30 individuals, with relevant knowledge and experience, was deemed adequate. By this process 30 interviews were conducted.

All interviewees had of the interview process had prior knowledge of the BIM. The pool of responses collected has been diverse in its experience, education and the organization they belong to. Academic qualification of interviewees is show in Graph-1, level of education of maximum interviewees is Masters.

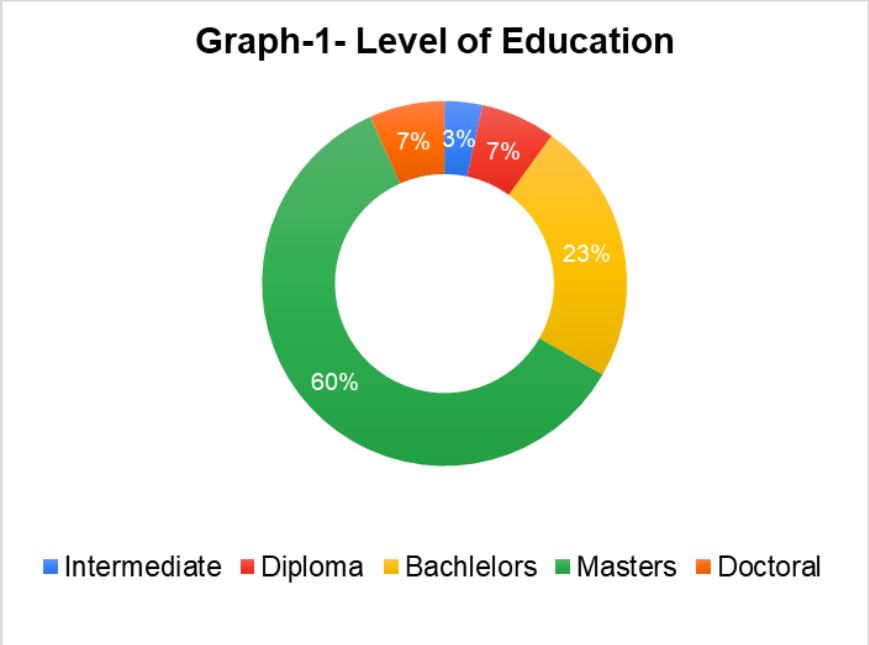

Figure 3 Level of Education of Interviewees

All of the interviewees have had some experience in field with 4 interviewees having 0-3 Years of experience, 14 having 4-6 Years, 6 having 7-9 years, 2 having 10-12 years,1 having 13-15 years, 1 having 16-18 years and 2 having 19-21 years of experience.

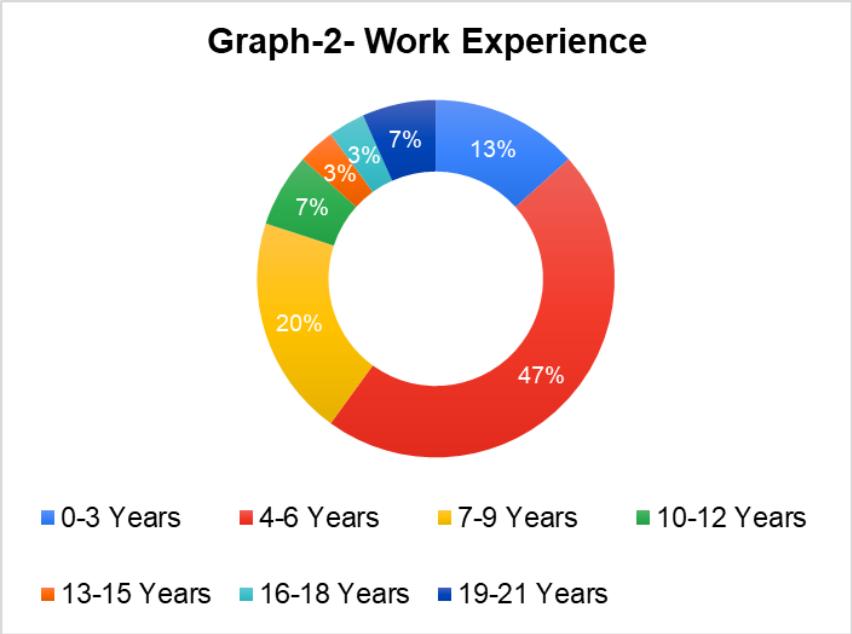

Figure 4 Work Experience of Interviewees

Further, interviewees belong to diverse organizations. 5 of the interviewees belong to Client, 13 to Consultant, 9 to Contractor and 3 interviewees belong to academia.

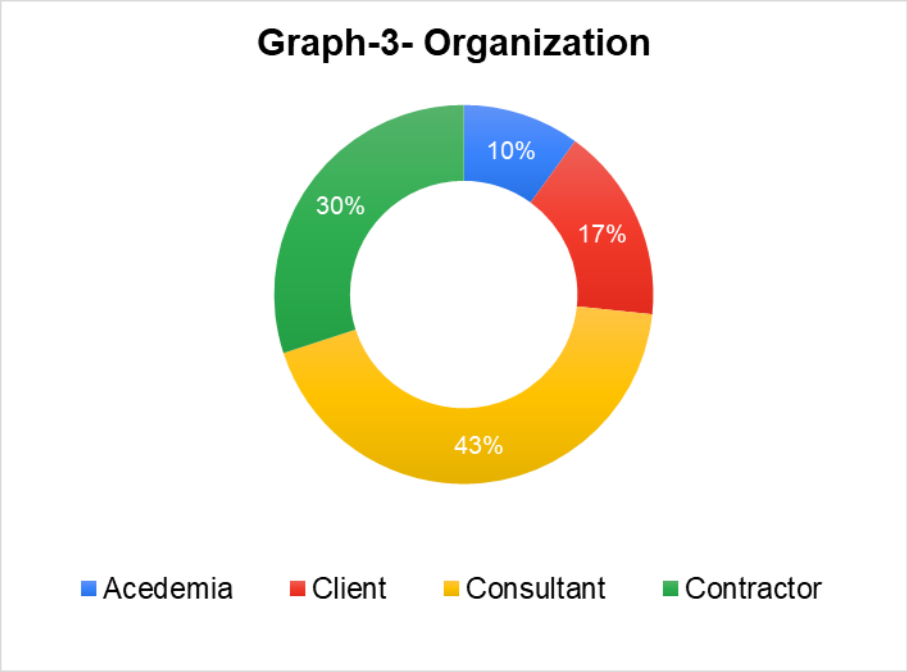

Figure 5 Organization of Work of Interviewees

The responses from these were then analyzed by taking mean of all responses on each question. Warmbrod in his paper discusses that the responses from Likert Scale 3 and above are considered above neutral. In taking the mean of each head, all the responses collected show that the mean answer of each head is not less than 3. Hence, as all the responses for each question carry above 3 mean weightage all of these responses were deemed critical. The results of the survey are shown in Table -4 given below.

Table 5 Results of Field Survey

Description	**Mean**	**Status**
What is BIM	4.300	Acceptable
Need For BIM	4.500	Acceptable
Global BIM	4.167	Acceptable
Benefits/Uses of BIM	4.467	Acceptable
Challenges to BIM	4.067	Acceptable
BIM in {subject Country}	3.300	Acceptable
Purpose of the Book	3.800	Acceptable
Infrastructure/ Horizontal Cons.	3.933	Acceptable
Interoperability	4.167	Acceptable
IFCs	3.833	Acceptable
Combined/Interdisciplinary Models	3.667	Acceptable
Common Data Enviroment	3.900	Acceptable
Communication/Collaboration in BIM/COBie	4.233	Acceptable
Contractor Selection	3.733	Acceptable
Contract Types and BIM	3.733	Acceptable
Stages to BIM Adoption	3.967	Acceptable
Work Flow of BIM	4.133	Acceptable
Model Planning	4.300	Acceptable
LODs	4.167	Acceptable
Facilities/Asset Management	3.767	Acceptable
Hardware and Software Requirements	4.167	Acceptable
Project Brief in BIM	3.933	Acceptable
Execution Plan for projects in BIM	4.000	Acceptable
Information Requirements	4.000	Acceptable
File Naming Convention	3.900	Acceptable

Description	Mean	Status
Presentation Style	4.000	Acceptable
Analysis & Simulation in BIM	4.133	Acceptable
Roles & responsibilities in BIM	3.967	Acceptable
Project Management in BIM	4.133	Acceptable
Ownership of Models	3.800	Acceptable
Security of Data	4.100	Acceptable

3.4 Selection Of Reference Documents

In the initial steps of this study 52 documents were gathered from the around the globe. These documents ranged from all over the globe encompassing all forms of BIM books. BIM Books contained Guidelines, Standards and Handbooks published by organization of different backgrounds i.e. Government Bodies, Private entities, Universities etc. However, for further study only the books of national scope were considered. These books were further shortlisted based on the scope of these books. Guidebooks aiming towards the wider adoption and implementation of BIM were considered. Hence, following criterion was set for the selection of Books for further study:

i. Only National level handbooks

ii. Only books published in English Language

Based on the above criterion the books were shortlisted. For this purpose preface of these books was read along with detailed study was done to ascertain the scope and audience these books were considering to address.

Further, only one guide was selected from each country. In case any country had more than one Guidebooks, the guidebook from prominent agency was chosen. For example, United Satates of America has the most number of guides published in the world. In this National BIM Guide (NBIMS) was chosen, instead of Guide by GSA Guide.

Further weight was given to contemporary latest guides and the extensiveness of these books.

Table 6 Reference BIM Guidebooks

Sr. No.	Country	Name of Book
1	United States of America	National BIM Standards – USA (NBIMS-US)
2	United Kingdom	AEC UK BIM Protocol
3	Canada	CAN BIM Protocol
4	Finland	COBIM
5	Hong Kong	Hong Kong BIM Specs
6	Norway	Statsbygg BIM Manual
7	Singapore	Singapore BIM guide
8	Belgium	BIM – Belgian Guide for Construction Industry
9	Australia	NATSPEC National BIM Guide
10	New Zealand	NZ BIM Handbook

This taxonomy of these books differs in different regions as the terms “Handbook”, “Guidebook”, “Protocol” and “Standard” is used interchangeably. However, based on the assessment criteria set above all of these books satisfy the conditions necessary for consideration in further study of these books for reference. Further, these books were searched across multiple platforms through the use of search engines on the world wide web such as Google, Web of Science and Google Scholars.

3.5 Correlation Summary

Upon studying these books in depth and analyzing the content of these books, the content present in these books was correlated to finalized heads. It was studied how

these books detailed and addressed separately the contents of the heads of our study. With minor change in taxonomy all of the books included in varying detail the required content.

Table 7 shows the an approximated summary of the different topics addressed in these books. How much a topic was discussed was taken as the factor used to summarize the content of these books. The scores are based on the detail of the review topic in BIM guidelines. The empty fields show that the a specific topic was not used in the a BIM guidebook. To mark the different levels of content details, numerical scoring system was used. If a content was not present then 0 is used, if the concerned topic is mentioned but not discussed in detail then 1 is used, for detail description 2 and for in depth discussion 3 was used. Books are mentioned in a vertical axis while review topics are mentioned in horizontal.

Table 7 Summary of Content from BIM Guidebooks

BIM Guidebooks / **Finalized Heads**	National BIM Standards – USA (NBIMS-US)	AEC UK BIM Protocol	CAN BIM Protocol	COBIM	Hong Kong BIM Specs	Statsbygg BIM Manual	Singapore BIM guide	BIM – Belgian Guide for Construction Industry	NATSPEC National BIM Guide	NZ BIM Handbook	**Frequency**
Interoperability	3	2	3	3	1	3	3	3	2	1	10
LoDs	3	2	1	3	2	1	1	3	2	1	10
Analysis & Simulations	2	1	1	1	2	3	2	3	3	2	10
Contract Types & Delivery Methods in BIM	2	3	3	3	3	1	2	1	2	3	10
Workflow in BIM	2	3	1	2	1	2	3	3	2	3	10
Contractor/ Consultant Selection	3	1	1	1	3	2			1	1	8
Project BIM Brief	1	3	3	3	2	1	2	3	1	3	10
Project BIM Deliverables	2	1	3	2	2	1	2	3	3	2	10
BIM Execution Plan	1	2	1	2			1	2	3	1	8
Ownership of Models	2	1	2	2			1	2	3		7

BIM Guidebooks / **Finalized Heads**	National BIM Standards – USA (NBIMS-US)	AEC UK BIM Protocol	CAN BIM Protocol	COBIM	Hong Kong BIM Specs	Statsbygg BIM Manual	Singapore BIM guide	BIM – Belgian Guide for Construction Industry	NATSPEC National BIM Guide	NZ BIM Handbook	**Frequency**
Security of Data	2	2	2	1			1	2	3		7
Roles & Responsibilities	2	2	3	3	3	2	1	2	3	3	10
Model Planning	2	1	2	3	3	2	1	2	3	2	10
Combined Interdisciplinary Models	2	1	2	3	1	2	1	2	3	1	10
Communication & Collaboration in BIM	2	1	2	3	3	2	1	2	3	3	10
Common Data Environment	2	1	2	3	1	2	1	2	3	1	10
File Naming Conventions	2	1	2	3			1	3	3		7
Presentation Styles	2	1	2	3	2		1	2	3		8
Hardware & Softwarer Requirements	2	1	2	3	1	2	1	3	3		9
Facilities & Asset Management	2	1	2	3	3	2	1	2	3	3	10
Infra and Horizontal BIM	3	1	2	2	3	1	2	1	1	1	10
Score	38	28	38	46	33	25	25	40	49	29	

3.6 Defining Parameters For Each Head:

To develop the content for each head it is necessary to first define the scope of each head. This to ensure that the content conforms to a minimum standard and also to facilitate ease of understanding of each term used. It is also pertinent to note that the discussion of heads further is only limited to the functional heads listed below.

i. Interoperability:

The ability of computer systems or software to exchange and make use of the information. BIM advocates the open exchange of information.

ii. Neutral File Formats & COBie:

Industrial Foundation classes or neutral file sharing format that facilitate the information exchange between different proprietary software.

iii. LoDs:

Level of Development is the degree to which the element's geometry and attached information has been thought through – the degree to which project team members may rely on the information when using the model. This section would discuss the use and definition of LoDs for Pakistani practices.

iv. Analysis and Simulations:

Through BIM many analysis and simulations can be run while the project is still in the design phase i.e. Structural Analysis, Clash Detection, energy analysis etc.

v. Contract Types & Delivery Methods:

Different contractual arrangement i.e. delivery methods may change the flow of information and processes. In BIN, it changes how different parties communicate, coordinate with each other.

vi. Workflow in BIM:

BIM Workflow is a set of processes that include the creation of models, maintenance and handing over the models for complete execution of the project

vii. Contractor/ Consultant Selection:

It relates to the qualification/Experience of the designer or consultant/Contractor, responsible for designing and managing the BIM model before award of contract.

viii. Project BIM Brief:

The project BIM brief is a subset of the project requirements, or equivalent contract documentation. It introduces the project team to information requirements, reasons, and purpose, along with technical and commercial details that should be addressed through the implementation of BIM.

ix. Project BIM Deliverables:

These are dictated by the client, chartering out all the necessary details or outcomes that should be included in the BIM Model and a product of BIM process.

x. BIM Execution Plan:

Perhaps the most crucial part of BIM framework. BIM execution plan identifies and outlines how BIM will be planned, executed, and managed throughout the design phase of the project.

xi. Ownership of Models:

Client is usually the owner of the model and it is ultimately handed over to him.

xii. Security of Data:

Information shared in BIM should be confidential and guidelines should be provided as to which measures should be taken to safeguard critical project information

xiii. Roles & Responsibilities:

Working on BIM requires its own set of individual professionals who work on different aspects of BIM and who are necessary in successful implementation of BIM principles.

xiv. Model Planning:

The process of planning and organizing the modeling process should be addressed in the beginning and modeling practices should be codified. This section discusses common industry practices.

xv. Combined Interdisciplinary Models:

Models of different types and trades are combined and federated into one central model.

xvi. Communication and Collaboration:

Communication in BIM becomes easier as 3D models are much less susceptible to misinterpretation than 2D information.

xvii. Common Data Environment:

The common data environment (CDE), is the single source of information used to collect, manage and disseminate documentation, the graphical model and non-graphical data for the whole project team

xviii. File Naming Conventions:

Client requirements detail a set a rules that require the naming, sharing and storage of BIM models

xix. Presentation Styles:

Many client organizations have a very specific presentation styles i.e. color codes and drawing different aspects.

xx. Hardware & Software Requirements:

It details the hardware and software requirements needed for adoption of BIM.

xxi. Facilities & Asset Management:

It is the Operation and Management of built facilities through BIM, once the construction stage is over and model is handed over.

xxii. Infra & Horizontal BIM:

BIM is generally considered catering only to the Vertical or Buildings, however, infrastructure / horizontal information modeling is also an integral part of the BIM process.

3.7 Classification Of Heads

In available literature regarding the BIM Handbooks, the content of the books are bifurcated into two main categories. These categories are based on the defining characteristic of each head. These heads termed as the *Descriptive* and *Prescriptive*.

Descriptive frameworks are characterized as *"explaining an existing phenomenon, describing and simplifying its knowledge domains"*. Whereas, "*prescriptive frameworks prescribe methodologies to follow."*(Holsapple & Joshi, 1999). These frameworks are aptly adopted for further classification of finalized heads. The need of reassessment of category of each head arose once in-depth study of these heads was done in order to proceed further for the creation of tailored content for each head.

Many heads needed only descriptive knowledge to give an understanding of different aspects and functionalities of BIM. These were categorized into a descriptive category. The content of these heads would be based on the available body of knowledge most relevant to current needs of industry.

On the other hand the prescriptive heads are more detailed as these contain information regarding the implementation of BIM in practical steps. These need to be adhered for the successful implementation and operation of BIM platform in construction industry. For these heads, not only were the available knowledge was consulted but also the prevalent practices of the market. Hence, the heads were categorized as following into above mentioned two categories:

Table 8 Categorization of Heads

Sr. No.	Heads	Status
1	Purpose of this Book	Descriptive
2	Intro to BIM	Descriptive
3	Need for BIM	Descriptive
4	Benefits / Uses of BIM	Descriptive
5	Challenges to BIM Adoption	Descriptive
6	BIM in Pakistan	Descriptive
7	Global BIM Perspective	Descriptive
8	Interoperability	Descriptive
i	Neutral File Formats	Descriptive
ii	Cobie	Descriptive
9	LoDs	Prescriptive
10	Analysis & Simulations	Descriptive
11	Contract Types & Delivery Methods in BIM	Descriptive
12	Workflow in BIM	Descriptive
i	DBB	
ii	DB	
iii	IPD	
13	Contractor/ Consultant Selection	Prescriptive
14	Project BIM Brief	Prescriptive
15	Project BIM Deliverables	Prescriptive
16	BIM Execution Plan	Prescriptive
17	Ownership of Models	Descriptive
18	Security of Data	Descriptive
19	Roles & Responsibilities	Prescriptive
20	Model Planning	Descriptive
21	Combined Interdisciplinary Models	Descriptive
22	Communication & Collaboration in BIM	Prescriptive
i	Common Data Environment	Prescriptive
ii	Collaboration Through Physical Means	Prescriptive
23	File Naming Conventions	Prescriptive
24	Presentation Styles	Prescriptive
25	Hardware & Software Requirements	Descriptive
26	Facilities & Asset Management	Descriptive
27	Infra and Horizontal BIM	Descriptive

It is pertinent to note that these heads were of prime importance which were finalized after input from Pakistani industry and these were deemed to be of the prime importance. The industry through above mentioned survey deemed these heads to require further elaboration. However, all of these heads are not mutually exclusive, hence, some of the above mentioned heads are included in the subheads of heads of larger scope. So that, these heads can be explained in depth as well as in a wider scope.

3.8 Content Creation Of Descriptive Heads

As explained above, descriptive heads contain description and explanation of a certain concept. For content creation of each descriptive heads, each document was scoured for relevant content or any information regarding the relevant head. This information was then used to develop the content of each head. As mentioned in the table 7, varied of level of information existed on each head. Some documents only mentioned certain aspects of a functional head. Some on the other hand contained more advanced information regarding a specific head. Since Pakistan is still in its nascency in BIM, the basic information needed for each head with functional knowledge was added to our head.

An example of this process is shown in the table below. An example of the content creation for head of Interoperability. As shown in the table below, detail of description of content of each head is given against each book. National specification for BIM in Australia warns regarding the dangers of data loss in data sharing in between different software, but does not go much in detail regarding different aspects of data transfer between software. It only gives a general information regarding information sharing. Similarly, in case of Belgian BIM guide, the book shares information on structured information sharing in BIM and the use of parametric modeling software. However, the

book does not prescribe the use of any format of IFC or detail which type of format shall be used for a specific purpose.

Table 9 Content Analysis - Interoperability

BIM Handbooks	Little Detail	Mentioned in Detail	Too Advanced
NATSPEC AUS		As per Market Practice	
Belgium Guide		Insists on Structured Information Sharing with no mention of IFCs	
Canada BIM Book	Only protocols in BXP		
Finland	No detail given		
Hong Kong	Talks about IFC Compliance but no detail		
New Zealand	Doesn't detail the protocols.	Insists on Common Data Environment	
Norway			Detailed instruction on Interoperability and file transfer formats is given with protocols.
Singapore	Open File formats are insisted upon. No detail of File formats.		
UK	Only Mentioned		
USA			Insists on detailed specific file formats for data transfer

While the other books mentioned either do not discuss the topic at all or only informs about the existence of interoperability. Taking the note of current state of Pakistan's BIM infrastructure, it was best decided to follow the middle approach. While the BIM usage in Pakistan is still very minute, use of BIM authoring software environment of multiple companies is unheard of. Hence, while developing the content of this head,

detailed explanation was given into the concept of Interoperability with explanation of Open and Closed BIM and Neutral File formats.

Open BIM is an environment where BIM software from a single authoring company are used i.e. all software used, for multiple purposes, are provided AutoDesk. While in Closed BIM software from multiple companies are used. Further, the concept of neutral file formats such as IFC is explained in detail for implementation of BIM in any open BIM environment where data sharing between multiple software platform are necessary without data loss.

3.9 Content Creation Of Prescriptive Heads

For creation of content of prescriptive heads, a different approach was used. Prescriptive heads should contain specific instructions that need to be followed for each aspect. Hence, these heads required detailed study. A mix of literature review from above sources and a study of documents from contemporary sources from different national level organizations was used. For example, to cater for the content of head of Contractor and Consultant selection, RFP documents from different organizations were used to identify the factors that were most considered before engaging in a contractual relation. For this purpose, the RFP documents from National Highway Authority, Federal Government Employees Housing Authority and Defense Housing Authority Gujranwala documents were taken as reference for the criteria used in selection of consultant and contractor. Moreover, an example for the content analysis for the creation of template of BIM Execution Plan is given below.

BIM execution plan is the most important document in the adoption and implementation of BIM in any project of any organization. This single documents details and encompasses all the functional aspects necessary for the successful implementation of

BIM process for any project. Similar approach as mentioned in Descriptive head example was used, as shown in the table below. Following the data collection on the subject of BIM Execution Plan, the data was scrutinized in Pakistan's context. More advance features, such as geo-positioning etc. were left out. Whereas, more relevant content, such as the data of the executing party were added. This document contains information regarding all major aspects of the execution of project through BIM. Information regarding use of standards, requirements/ qualification of contractor and consultant, BIM goals, communication methodology, quality control checks for the model etc. were all covered in the document. Since BIM Execution Plan lays out structured plan and all aspects of execution through BIM, a template for BIM execution Plan was also needed. Hence, BIM execution plan template was also developed and added at the end of the documents to provide a reference document for any organization hoping to implement BIM in construction projects.

Among the prescriptive heads, following templates were produced as the annexures:

i. Annex-A – Project BIM Brief
ii. Annex-B – BIM Execution Plan
iii. Annex-C – BIM Documentation Practice
iv. Annex-D – BIM LOD
v. Annex-E – BIM Modeling Guidelines
vi. Annex-F – BIM Roles and Responsibilities

Table 10 Content Analysis – BIM Execution Plan

BIM Handbooks	Little Detail	Mentioned in Detail	Too Advanced
NATSPEC AUS			Mentioned in detail with detailed appendices mainly concerned with LoDs at different stages of the project
Belgium Guide	Refers to it in bits and pieces. No template.		
Canada BIM Book		Covers in sufficient detail. All necessary processes included. Based on Integrated Project Delivery Method	
Finland	Mentions the process in spirit. No Template.		Design Stage mainly focused in excruciating Detail
Hong Kong	Mentions the process in spirit. No Template.		
New Zealand		Template given in sufficient detail, concerned with execution Phase	
Norway	Mentions the process but no template is given.		
Singapore		Covered in sufficient detail. Easily followed to incorporate BIM in construction Process.	
UK		Pre and Post contract BIM execution Plans are given.	
USA			Thorough explanation and guide available.

3.10 Content Creation Of Prescriptive Heads

The process of content creation as described above was used for the all the finalized heads. The finalized heads were placed together to form a single coherent document.

The handbook starts with purpose of the book and introduces the concept of BIM, its need and uses for Pakistan's AEC industry. Afterwards, the functional aspects of the book are placed giving information regarding different uses of BIM. The templates were placed at the end of the book.

CHAPTER 4 RESULTS

4.1 Final Feedback

Once the draft of the guidebook was created the document was then sent for review. Townsend (2013) and Holsapple (2009), both argue that semi structured interviews are best used for collection of qualitative open-ended data. Semi-structured interviews are an effective method of collection of data where responses are based on interviewees own strengths and experiences. Hence, the review of the final draft of BIM handbook was done by the method of Semi-structured Interview.

The interviewees were approached based on their experience and knowhow on the subject of Building Information modeling and it's implementation. The participants were given the BIM handbook in advance and given time to read and review it. Afterwards, the interviewees were asked questions about the handbook.

The first part of the interview was designed to include professional information regarding the interviewee i.e. the field of work, qualification, knowledge and years of experience relating to BIM. The second part of the interview focused on the questions regarding the BIM Guidebook.

The interviewee was asked a series of questions. Some of the questions were to be answered on Likert Scale in range of 1 to 5 while the others were open ended questions which required a detailed response, account or review of the interviewee pertaining the BIM Guidebook.

4.2 Review Of The Handbook

Townsend discusses in his paper that the sample size of such surveys in the range from 5 to 25 is enough (Townsend, 2013). For our research 16 responses were collected. Demographics for the above review are given below.

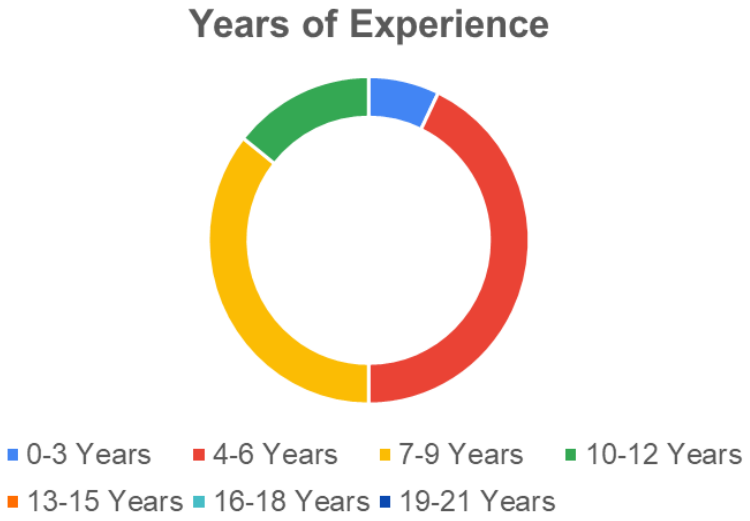

Figure 6 Years of Experience of Participants for Final Feedback

The participants all ranged in experience in upwards of 3 years. Only participants with prior experience in BIM were contacted. All of the interviewees have had some experience in field with 7 interviewees having 4-6 Years, 5 having 7-9 years and 2 having 10-12 years of experience.

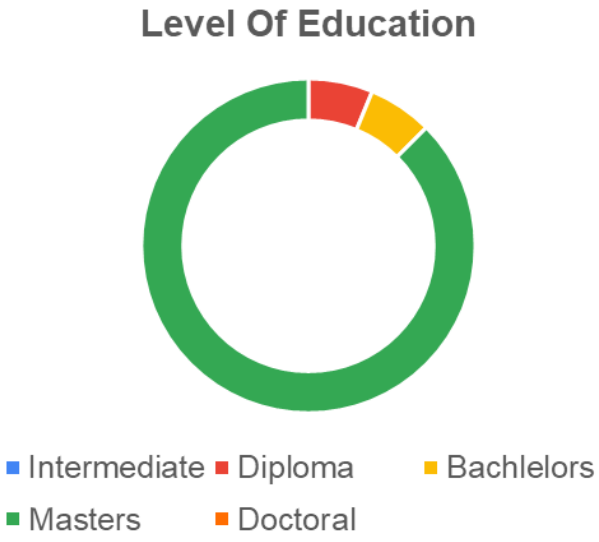

Figure 7 Level of Education of Participants for Final Feedback

14 of the 18 participants had Masters level of education. While 1 participants each had an education level of bachelors and diploma.

Figure 8 Organization of Participants for Final Feedback

Further, interviewees belong to diverse organizations. 5 of the interviewees belong to Client, 5 to Consultant, 5 to Contractor and 1 interviewees belong to others category.

The results and review was overall positive. Most participants applauded the effort of BIM Guidebook and offered their valuable input. A few suggestions were made by the interviewees which were subsequently addressed.

4.3 Responses

Participants were asked about their opinion on different sections and aspects of BIM. Both quantitative and qualitative questions were asked. One of the question pertaining to the usefulness of this book in adoption and implementation of this BIM in Pakistan, the mean answer on Likert Scale came out to be 4.125. Hence, the responses were positive.

However, when interviewers were asked about their opinion on different heads of BIM in an open ended questions, multiple responses were received as follows.

Figure 9 Queries and Responses Of Final Feedback

Queries	Response
Mention Standards	The choice of standards lies with the governing Body. Addressed in BIM Execution Plan
Benchmarking of BIM Implementation	Benchmarking systems are present in more advanced use cases countries. However, for Pakistan at this stage none exist. Literature exists on this topic and can be adopted as per client mandate.
LoD standards and Roles	LoD templates for both UK and USA are given and can adopted as per choice. Moreover, a template for roles and responsibility also exists that should be addressed at the beginning of the project.
Practical Examples	Examples of BIM adoption are addressed in the beginning. However, detailed case studies are not included in the scope of this book.
Plug-ins	Out of Scope of this research.

Since the industry in Pakistan is in nascency, understanding of a BIM handbook was scarce. Hence, while some responses very useful in multiple functions of BIM, they exceeded the scope of this research, as explained above.

After addressing all of the above mentioned concerns, the BIM Handbook for Pakistan was finally created, document attached in Annexure-i of this document.

CHAPTER 5 CONCLUSION

BIM implementation and adoption is a complex process in general. Knowledge of multiple aspects of BIM science and process is a must before such undertaking. However, documents developed as a result of this research could help ease the transition from traditional method of construction towards a BIM based approach. A thorough evaluation and analysis of many BIM papers, BIM Handbooks, guides, roadmaps and standards was done which was then carefully curated for the needs of Pakistan's AEC industry to aid in adoption and implementation of BIM.

Construction client organizations believe that the adoption of BIM needs to be accelerated given the advantages that can be realized through collaboration and data integration. Given the fundamental nature of the change, one of the tools is to establish policy frameworks expressed in the form of national standards, collaboration guidelines, and/or project-level BIM execution plans. Due to the abundance of these organizations, misunderstanding among architects, engineers, and builders may result from the establishment of a comprehensive collection of BIM guidelines with varying standards.

This study may aid in the creation of standardized or harmonized BIM guide templates for various organization types, which would lessen the likelihood of misunderstanding.

In developed nations with advanced use of BIM and a robust BIM environment many different organizations have developed their own standards and guides which, potential partners in the form of contractors and consultants or other business associates, would need to consult to cater to their specific needs. It is our hope that in the future Pakistan's multiple client organization would build their own versions of this BIM handbook.

Annex-i

BIM HANDBOOK PAKISTAN

PAKISTAN BIM HANDBOOK

v 1.0

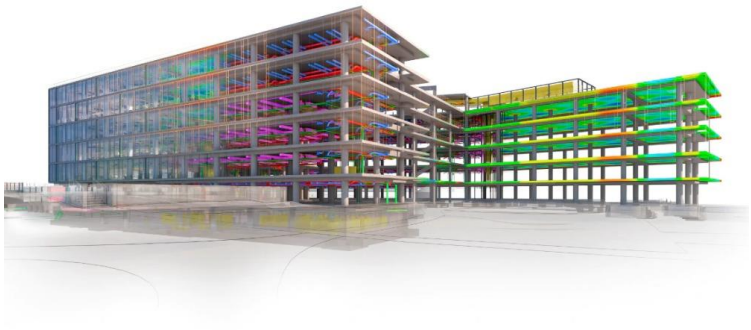

Table of Contents

1. PURPOSE OF THIS BOOK

This handbook provides a central reference point to help navigate readers' way into the adoption and implementation of Building Information Modelling (BIM) in their respective organizations in Pakistan. It aims to equip Government and public sector construction clients with the knowledge to adopt and implement BIM in their respective organizations.

It is a structured guide to introducing BIM technology. The knowledge provided here has been carefully selected and modified for the Pakistani perspective, driving inspiration from well-established sources such as the GSA BIM book of America, New Zealand BIM Handbook, Statysbygg BIM Book, and more. This document points to and encourages the use and application of BIM to reap wider benefits for the construction industry of Pakistan.

2. INTRO TO BIM:

Building Information Modelling (BIM), the term first realized by Chuck Eastman in 1970, has been in use under different terms for more than two decades now. BIM is positively transforming the construction industry in definitive steps rather than slow gradual changes, aptly termed as the game-changer. The National Building Information Modeling Standards (NBIMS) Committee defines BIM as:

"…a digital representation of physical and functional characteristics of a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition. A basic premise of BIM is a collaboration by different stakeholders and different phases of the life cycle of a facility to insert, extract, update or modify information in the BIM to support and reflect the roles of that stakeholder."

This 3D technology has revolutionized the world of construction. A 3D basic geometric model of a facility is constructed. The 3D model forms the basis for all further processes, to be performed using this technology.

BIM encompasses complete processes and functions needed to model the building life cycle of a project in its entirety. BIM Is not only a product containing the 3D model of the project but also a process detailing the information exchange in the project between different stakeholders in a systematic way where all updated information is accessible to all.

3. NEED FOR BIM

BIM remains the only tried and tested solution for the cost and time overruns catering to the uncertain nature of the construction projects. Although numerous studies exist on the topic, the expectation of smooth implementation and good results on ground is not realistic. The gap remains on a basic level as to the understanding of the core concepts and the application of BIM. Guidelines published by other countries and the positive feedback they have received after the implementation of guidelines provides inspiration for this study.

4. BENEFITS/USES OF BIM

BIM implementation around the globe has made the construction industry stakeholders aware of the wide range of advantages it brings. Countries with advanced BIM use have accepted it as the way forward. Many of the developing nations have made it mandatory part of the construction process through legislation such a UK, Sweden, Finland, Denmark, Singapore etc. Yet in Pakistan, we stand at the precipice of BIM, only now starting the implementation process at the rudimentary stage. Although there is very little use of BIM, many studies have been done to see what benefits this technology could bring to the industry. One such study done in 2016 has outlined following benefits to the adoption of BIM:

- Reduced construction Cost
- Reduced construction time
- Improved Quality
- Reduced Human resources
- Reduced Contingencies
- Faster and more effective method
- Reduce rework during construction

These results were based on data collected from 102 Pakistani construction industry professionals. The participants had a varied level of experience in terms of years and belonged to diversified backgrounds i.e. Client, contractor, consultant, specialist tradesmen etc.

Another research, done more recently, in 2022 has reinforced the same points as above, with addition of the following:

- Client satisfaction
- Time reduced in drawing production
- Improved programming of Schedule
- Increased productivity, safety and schedule
- Creative and innovative method of solving engineering problems
- Improved coordinate drawing
- Less errors in data
- Single detailed mode

5. CHALLENGES TO BIM ADOPTION

BIM implementation in the world has increased exponentially over the past few decades. Only in 2007 the awareness of BIM was recorded to be 26% while in 2016 it had jumped to 56%. (Imtiaz, 2018). While in Pakistan the research shows that only 11% of the AEC industry has adopted BIM in various shapes and forms (Imtiaz, 2018). Although, there are ample studies and research data available online regarding multiple functions of BIM, the adoption and implementation of BIM remains abysmal.

As per already published research following are the factors hampering the adoption of BIM in Pakistan:

- Higher Initial Cost
- Lack of Awareness
- Lack of training of new technologies by firms
- Resistance to change
- Traditional method of contracting
- Lack of expertise
- Complexity of software
- Lack of support from stakeholders
- Costly in learning and training staff

These factors identified have been further supported by another study with the addition of another factor “non availability of parametric libraries”.

6. GLOBAL BIM PERSPECTIVE

Many of the nations have pushed for BIM deployment, the trend has been more apparent in the developed countries. By the North America is considered the leader in BIM adoption and implementation, with most public and private organization adopting BIM as the integral part of the construction process. On the other hand Oceania and Europe has seen the most advanced use of BIM. Africa and the Middle east is considered in the tier of BIM adoption phase, categorized in the beginners category. Asia is ranked fifth in the list in BIM engagement. Whereas south America comes last in BIM engagement.

The General Services Administration of the United States of America is leading the way in using BIM on public projects and has required BIM use for spatial programme validation since 2007. USA currently leads the number of publications related to adoption and implementation of BIM in construction projects and facilities management. Many of the public offices have developed their own standards for implementation of BIM and its use during and after the construction process.

United Kingdom has seen one of the most advanced implementations of BIM. Major factor contributing to its success is its adoption through policy mandating BIM use. CIC, AEC UK and BIM Task group has through various publications has produced multiple guidelines and protocols to facilitate the adoption of BIM. Currently 18 publications have been found ensuring smooth adoption of BIM as per UK standards. The industry as whole is moving towards the BIM Level 2 in capital delivery phase of the project.

Denmark, Norway, Sweden, Netherlands and Finland are now at the forefront of open BIM standards and protocols in the building design and construction sector has required the use of BIM on government projects since 2007. The Scandinavian area is perhaps the leading proponent of BIM interoperability, having created the technology

and vendor standard Industry Foundation Classes (IFCs), which is one of the most widely used format for collaboration in BIM. These are the countries who have taken a holistic approach to BIM and has already achieved implementation milestones through implementation of BIM in many large scale projects of national importance. These countries are rapidly working towards even advanced uses of BIM and providing practical solutions to many problems faced during the execution processes through BIM. Since 2010, Norway has required IFC compliant BIM, while the industry still needs improvements in order to provide further information sharing solutions.

Singapore, Korea, Japan, Hong Kong and Mainland China have surprisingly well developed BIM infrastructure. Singapore introduced BIM in the construction as early as 1995. Since then Singapore has actively worked towards developing a booming BIM infrastructure through government legislation and various roadmaps and trainings to educate the country's construction industry to ease the transition to BIM. Since 1995, Singapore has been leading Asia in BIM revolution by publishing 35 standards for BIM. Korea has also been working towards establishing a BIM culture. Many public bodies have been involved in developing BIM infrastructure through R&D. A lot of the work being done is to benefit from the functional aspects of the BIM such as cost estimation, energy analysis etc.

7. BIM IN PAKISTAN

Benefits of BIM have been well-established. Countries around the world have acknowledged the use and intended benefits in construction industry. For the case of Pakistan, as discussed earlier, adoption of BIM has met of resistance from industry due to a multifaceted reasons. However, one study performed before and after the execution of a Government funded Hospital in Mardan in Khyber Pakhtunkhwah province of Pakistan, highlights the all issues from design to execution phase. The results conclude strongly that the participants of the study and the stakeholders of the Project lean strongly towards BIM after the study highlighted the issues and their solution in BIM. Participants strongly agree that concessions in both time and cost could have been made with the implementation of BIM at earlier stages.

This is but one example of the countless issues the study can address by providing a solution towards implementation of BIM. One study done was on construction industry professionals working on CPEC(China Pakistan Economic Corridor). CPEC is a Multi-Billion Dollar infrastructure project of huge economic importance for Pakistan. The participants of the study have expressed their concerns regarding the cost and time over runs on this project of critical nature. The participants have overwhelmingly stated that the cost and time over runs frequently experienced by the construction projects in Pakistan can be reduced hugely through the use of a structured information disbursement system such as BIM.

The academic sector of Pakistan, specifically the graduate students, through publications have shown that there is robust application and research in BIM sector. In one study the students have used to tackle the growing threat of water scarcity. Through the use of BIM technology students calculated the potential of capturing rainwater in major cities of Pakistan. This study provides a basis for all future rain water harvesting projects that could become the need of the future. Similarly, another was carried out in Lahore, Pakistan to calculate the energy costs related to a residential building. This work studied in detail the costs related to heating and cooling of a building through its life cycle, taking in account its location, direction of sun, cost and effect of insulation, natural air flow etc. The basic 3D model was made on AudoDesk Revit while different software were used for simulations. Costs of the natural gas and electricity were also taken from SNGPL and WAPDA and LESCO. Another study in the domain of Green building and sustainability was done in Capital Islamabad, Pakistan, to calculate the energy use and its optimization. While above studies deal with the energy use of the building another ground breaking research study concern its self with the carbon foot print of building construction in Pakistan. For this purpose an educational building was used to study the common materials that were mostly used in construction industry of Pakistan. The study shows that thoughtful usage of BIM in the conceptual stage of the building can greatly reduce the wastage of materials, further better choices can be made for selection of materials that have less carbon footprint.

Once the end user of the AEC industry has the access to the benefits and knowledge of implementation of BIM, the effect of widespread use of this technology would be monumental towards saving the public and private sector in cost and time.

Despite serious challenges in awareness, Phase 1 of BIM is already under way as many individuals AEC professionals and some companies have started making use of BIM software in isolated capacities and for small scale projects. Smaller uses of BIM are include 4D and 5D BIM i.e. using 3D model based estimation and scheduling features. One other widespread use of BIM is using 3D Model for structural design of buildings.

8. INTEROPERABILITY:

Interoperability is the ability of the different computer systems and software to exchange and make use of the information. Information exchange between different computer systems and software is perhaps the core ideology of BIM. BIM facilitates the exchange of information in the most efficient and convenient forms. For the exchange of information, two core concepts are used:

- Open BIM
- Closed BIM

a. Open BIM:

Open BIM refers to the exchange of information through different file formats where minimal or no restrictions are placed on the software tools used for the modeling or

further information exchange. Mutually agreed or as defined in the Project Execution plan, information through different software is exchanged through IFCs or any other file format is used.

In the case of the use of Open BIM trials and tests should be performed at the initial stage to check software compatibility and that there is no loss of information when exchanged from one software platform to another.

b. **Closed BIM:**

Information exchange is generally more reliable and efficient in this form of BIM information exchange. In closed BIM vendor-specific modeling tools are used e.g. all software used for modeling and information exchange could be used from AutoDesk or Tekla as per the requirements set out in the Project Execution Plan.

Before the start of the BIM implementation, a detailed review of the client information requirements should be done, identifying the structure of information and contractual arrangement through which must be administered. These Interoperability requirements should be sorted out and agreed upon at the initial stage of the project after the data has been identified.

a. **Neutral File Formats**

BIM encourages Interoperability, the most common path to which is led by Neutral File Formats. NFFs are non-proprietary and can be read by any number of BIM Software. The most commonly used BIM formats are:

i. IFC

Industry Foundation Classes or IFCs is a non-proprietary neutral and open file format. IFC is the most commonly used file format. It is a read-only file format hence these files can be used to extract data however, the file cannot be edited. The file format contains an object-oriented 3D model equipped with detailed readable information and interconnections between different building elements. The first version of IFC, IFC 1.0 was used in 2000, currently, the latest certification is dubbed IFC 4. Another version of IFC most commonly used is IFC 2x3.

Although IFC is the most commonly used file format, advanced uses of this function show that some data may be compromised when exchanging data between tools from different software vendors. Hence, it is best to mention which goal is best served by a specific version of IFC in the BIM Execution Plan.

ii. COBie

Construction Operation Building information exchange is a system of information exchange developed to log and save detailed data regarding the complete construction process for use in later stages of the project. COBie in itself contains templates for use. These templates are thorough in nature. It is a good practice to specify which version and tables are to be used for a particular goal.

9. LODS (LEVEL OF DEVELOPMENT)

The Level of Development (LOD) scale is used to indicate the consistency of material that should be supplied for certain model components at various stages of model development. When LOD is used the major goal is to define what each member of a design/construction team is responsible for authoring in their models at each step, and to what degree others may depend on them. At any step of delivery, project models will usually include aspects from previous stages of development.

The client should specify the appropriate level of detail (LOD) for BIM information that supports the project's organizational and project objectives. Further, it is advised that the concepts of Lod (Level of Detail) and LOI (Level of Information) may also be incorporated in while publishing modeling guidelines. This gives a better understanding and understanding for the project participants regarding information required at a specific stage. A template is attached in Annexure-D.

c. Level of Detail:

LOD is often misunderstood as Level of Development rather than Level of Detail. There are, nevertheless, significant distinctions. The level of detail refers to how much information is provided in a model element. The degree to which the element's geometry and related information have been thought out – the degree to which project team members may depend on the information while utilising the model – is referred to as the Level of Development.

In essence, the degree of detail is the element's input, while Level of Development is the element's dependable output.

d. Level of Information:

The Level of Information, or LOI for short, is a term used to define the information level of a BIM object at a certain point in the project. The qualities of an item, such as size, material specifications, insulation, or the expenses of a construction part, are referred to as LOI.

10. ANALYSIS AND SIMULATIONS

There are already a number of third-party programmes on the market that can execute simulations and/or analyses inside 3-D modelling tools (e.g. Revit). The findings must be brought back into the Revit 3D Model regardless of the programme used to execute simulations and/or analyses inside the 3-D modelling applications (s). This ensures that the Revit 3D Model has the most up-to-date information.

This is one of the huge benefits of the 3-D Model as its applications and the number of simulations that can be performed are endless. Some of these areas and their uses as follows:

- Visualization
  - View of Building Elements

- Visualization of major building elements and aesthetics
- View of Building Interior used for space management
- Video Simulations of the building

• Structural Analysis
  - Identification of all major structural elements
  - Identification of loading capacity of these elements

• Energy use and Analysis
  - Calculation of the energy needs of the building over the project life cycle and use
  - Code Compliance
  - Any building codes and standards can be verified through visual inspection

11. CONTRACT TYPES & DELIVERY METHODS IN BIM

The use of BIM can be facilitated with any number of contractual agreements. The philosophy of BIM is ever-encompassing and can be used to achieve the best possible outcome that is in the best interest of the project and the owner. With BIM there is no one size fits all approach and contractual arrangements should be made based on how a certain arrangement will best serve in the execution of the project at hand.

Keeping that in mind, the two most commonly used delivery methodologies used in Pakistan have been mentioned below along with an additional methodology that may be best suited when using BIM.

a. Design Bid Build
b. Design Build
c. Integrated Project Methodology

Design Bid Build

Traditional projects, most commonly are based on Design-Bid-Build. It is a widely used system that is understood by all contracting parties. The Owner or client usually hires the designer after establishing the need for a project and then goes on to the bidding process. Through this process, the contractor is hired who is responsible for the construction of the said project.

Although, all the contracts are drawn from the client, BIM is implemented in this process in a lonely manner. Each party involved in this process does its part of the job and hands the product on to the next one. Even though all parties are involved contractually, with their own well-defined roles and responsibility matrices as discussed in the BIM Execution Plan, they all work in an individual manner, using the "lonely BIM" format.

Design Build

In the design Build format, once the contract has been drawn between the client and other party. The second party is responsible for both designing and constructing of the project. In comparison to DBB this method is able to able to exploit the benefits of the BIM much more. As the second contracting party is responsible for the design and construction, the aspect of coordination between the design and construction phase creates a much more BIM friendly environment through constant to and fro owing to a direct open communication channel.

e. Integrated Project Delivery Method

Integrated project delivery method is a relatively new delivery method first used in Sweden. Through this method the liability and profit is divided among all stakeholders. Where in conventional methods the responsibility is shifted step by step on to the next stakeholder for managing the process of construction through BIM, this method involves all stakeholders from the start. Once the conceptual stage of the project is finalized and the client wishes to proceed towards the design and construction phases, all stakeholders are involved during and after the design phase and into the construction phase. This contractual arrangement shares the risk and benefits of the project among all stakeholders, hence client is not the only party at risk till the project is finished.

Furthermore, as all parties are involved in all stages of project life cycle the collaboration, communication and information sharing is best accomplished using BIM. Due to the versatility of BIM process and the ease of sharing information stakeholders are shared up to date information that in turn benefits the project with faster decision making.

12. WORKFLOW IN BIM

Typical workflow of BIM may be established by the client or sponsoring organization. It mostly depends on the project deliver method. Since the two most dominant project delivery methods in Pakistan are Design Bid Build and Design Build methods, following are the two work flows that are usually followed for BIM implementation in a project.

f. Workflow Of Design-Bid-Build Projects

The BIM process is divided into two models in the standard Design-Bid-Build project delivery method: a design model and a construction model. The design model and tender papers are created by the consultants. The construction model is created by the Main Contractor for construction reasons.

Pre-Tender Stage:

- Establish a BIM execution plan prior to modelling;
- design teams create architectural and system models;

- integrate design models for coordination and clash detection;
- conflicts will be resolved interactively during coordination meetings;
- design and tender documents can be prepared once all conflicts have been resolved. Construction Stage:
- Models and/or drawings developed from the models will be handed to the main contractor for reference only;
- the main contractor will further develop the model with construction and fabrication details, as well as fully annotated drawings for/by the subcontractors.

g. Workflow Of Design -Build Projects

The Design-Build project delivery technique provides for the creation of a single model for construction documents and building system manufacturing.

- Prior to modeling, create a BIM execution strategy.
- Designers will generate BIM in schematic design in conjunction with subcontractors.
- models that adhere to project specifications
- For coordination and collision detection, combine the BIM models into a composite model.
- During coordination meetings, conflicts will be handled in an engaging manner.
- Construction paperwork may be created if all issues have been settled.
- Installation planning meetings will be held by the Design-Build team, where the coordinated installation will be discussed.
- For evaluation and field installation, the model will be utilized.
- Allows for the precise digital production of essential components off-site, such as
- precast components, prefabricated modules, structural steel

13. CONTRACTOR / CONSULTANT SELECTION

Contractor and Consultant selection is usually done after the conceptualization phase of the project. The process of choosing the right consultant/designer and contractor comes after the nature of the project becomes clear. The first step a client organization needs to do is to set project goals and requirements and develop a project BIM brief. After the development of project BIM Brief, formally setting out the requirements and expectations for the executing party, the legal process of selecting a contractor and consultant may begin.

The selection of contractor(s) and consultant(s) is based on the delivery method chosen for the project. Once the roles of each party have been established only then can the criteria for selection be set. These criteria are based on the set role each part

is expected to perform. Usually, the in traditional contractual arrangement following expectations are set:

- Consultant: Designing the project facility, sharing information with the client while keeping in check the BIM implementation process.
- Contractor: Keeping in touch with all stakeholders while and deliver all the required information, models, etc. along with the physical project.

Based on the criteria set by each organization the specific requirements vary for every client organization. After Cost, the following are the most common set of criteria included regarding BIM are as follows:

- Qualification
- Experience of the Staff in BIM
- Past experience in BIM
- Technical capacity of the Organization to create and manage BIM Environment
- Reputation (Financial and Legal)
- Organization structure of the team
- BIM Execution and management plan (for Contractors)

This set of criteria is given weightage as per the priority of the organization. Each applicant is judged based on the scores they receive as a result.

14. PROJECT BIM BRIEF (Client Information Requirements)

Project BIM brief is the first document that should be created in the initial stages of the BIM project. This is the first step toward project management through BIM. This document contains information regarding specific goals the client needs to be fulfilled through the implementation of BIM.

In this document, the client outlines the specific goals and objectives that they wish to achieve through the successful implementation of BIM. Each goal can be attributed to a specific BIM use. This document forms the basis for the BIM execution plan. It can also be used for generating and becoming part of an RFP (request for proposals), subsequently the Bidding documents. BIM Brief should be developed even before hiring a consultant for a project. If the client does not have the expertise in BIM to translate expected potential outcomes in terms of BIM, a BIM consultant should be hired. A template for Project BIM Brief is attached in Annexure-A.

15. PROJECT BIM DELIVERABLES

BIM project deliverables and timelines should be decided before the initiation of the project and once all the major stakeholders have been decided / chosen so that their participation can be accommodated. The following are examples of common deliverables:

- Model for a site
- Model of the massing
- Models for architecture, structural engineering, and mechanical, electrical, and plumbing (MEP)
- For regulatory filings
- For coordination and/or clash detection analysis, visualization, budgeting phasing program and schedule (materials, time, etc) (in BIM or spreadsheet)
- Models for manufacturing and construction

Data for facility management Shop drawings As-built model (in native proprietary or open formats) Other extra value-added BIM services

16. BIM EXECUTION PLAN

This is the most important document for a project's BIM implementation. It's an extension of the Project BIM Brief, and it's created collectively by the project executing team after they've been hired. It's a living document that may be modified as the design and construction stages progress. It goes through each of the client's objectives and how they will be met. The Project BIM Execution Plan assigns essential roles and specifies the processes, procedures, and tools to be utilized in the project.

The Project BIM Execution Plan will be transmitted from the design team to the construction team at the end of the design phase, where it will be modified and supplemented with construction phase BIM activities. The use and transfer of the BIM Execution Plan depends on the contractual relationship and the deliver method. These matters should be highlighted in the BIM Brief. A template for BIM Execution Plan is attached in Annexure-B.

17. OWNERSHIP OF MODELS

It is perhaps most important for the client organization to own and reuse construction data which is most beneficial for the client throughout the project life cycle. The BIM process should be able to produce nuanced data as per the requirement of the client to ease the process of facility management and other uses once the construction process has ended. The client organization, responsible for initiating the project and hiring the personnel has the ownership of all the models and files created through out the BIM process. And once the data has been delivered to client, it may be used as per the best interest and use of the client.

Any ownership rights exceptions should be specified in the project contract(s), recorded in the BIM Execution Plan, and authorized by the Project BIM Team. At the end of the project, the client receives ownership of the project data. The client reuse rights should be stated in the contracts between the client and the stakeholders.

18. SECURITY OF DATA

BIM protocols should be subjected to the client's current data security requirements. In terms of data protection, the customer should examine the security concerns. Data limitations processes, such as checkout and check-in, as well as stating the degree of access control for project participants, may be included by the customer. The customer should demand that the Project BIM Team create a Data Security Protocol that meets data security standards.

Clear and concise data sharing protocols should be developed and followed through each stage of the BIM process. The back up of data should be done on regular basis to avoid any loss or destruction of file or data during sharing. Sharing protocols are necessary to avoid data corruption, “virus infections," data abuse, or malicious destruction by project team members, other workers, or outside sources. Moreover, use access rights should not be granted with some due diligence and access to sensitive data should be restricted to passwords.

As part of the BIM Execution Plan, the Project BIM Team should create and present to the client a Data Security Protocol (DSP) that describes the project's security measures. Prior to beginning work, the client should approve the DSP. At the very least, the DSP should cover: User access rights and permissions, which should outline the different roles and levels of data access. The roles stated in this guide and the BIM Execution Plan should be correlated. Any extra user access that is necessary should also be identified by the DSP.

Data protection, which specifies how the data will be safeguarded against:

- Corrupted Data (malware, viruses)
- Negligence/misuse
- Accidental Loss
- Unauthorized transport
- Intentional assault (internal or external)

Procedures for data processing and handling protocol for:

- Exchange: How and how often data will be exchanged. The DSP should be consistent with other BIM Execution Plan criteria and give more particular data exchange information.
- Maintenance: Describe how all data sources, transmission devices, and storage devices utilized in the project will be maintained.
- Backup: Describe the Project BIM Team's backup strategy in detail, including backup frequency and retention.
- Archiving: Describe the Project BIM Team's archiving, retrieval, and retention system.

19. ROLES AND RESPONSIBILITIES

BIM roles and responsibilities hugely depend on the client organization and the project delivery method. In each case, a new roles and responsibilities matrix needs to be prepared and assigned in the BIM execution plan. In the case of Pakistan, in DBB and DB projects, two new specialists, known as BIM Managers for Projects and BIM Coordinators for Consultants and Contractors, have been designated in Annexure R to help with BIM procedures.

Depending on the expertise and knowledge of BIM existing project team members, such as project managers, CAD Manager, and contractors etc. may be considered for the same positions. The BIM Manager should guarantee that, in addition to ensuring that BIM goals are met, all stakeholders collaborate to resolve issues in the most effective manner possible.

Making choices on design, engineering, and construction solutions for the project, as well as organizational procedures for each discipline, are not part of the BIM Manager's job description. A template for assigning roles and responsibilities is attached in Annexure-F.

20. MODEL PLANNING

In general, the following practices should be followed:

- Model structure is of the utmost important and it should be agreed up by all the different design disciplines available which shall then be documented in the BIM Execution Plan.
- Only a single project should be modeled in a single file.
- Only one discipline shall be modeled in a single file. Same may apply to a project stakeholder. However, exceptions may be taken in cases such as services in a building, where multiple disciples converge.
- Further segregation of the geometry may be required to ensure that model files remain workable on available hardware.
- Ownership of the project elements and models should be clearly defined in the beging of the project in BIM execution Plan. So that even if the ownership of some element changes, duplication and other errors can be avoided.
- A federated or container model should be considered where multiple models consisting of each separate discipline are created. This model is there to link up all existing models together for the analysis purpose such as clash detection etc.

A template for detailing modeling practices is attached in Annexure-E.

21. COMBINED / INTERDISCIPLINARY MODELS

Different project members and modelers should share their models with each other periodically for reference. Regular synchronization of models from many disciplines should be done at particular stages, enabling relevant parties to settle possible disputes ahead of time and prevent expensive corrective effort and delays during the building stage. The relevant models should be examined, authorized, and certified as "fit for coordination" prior to model coordination (see section 4.5 for more information).

The project team should create a high-level coordination flow, that shows the interactions between the Employer and project participants. To accomplish the coordination efficiently, the project team might use the available software solutions. To limit the risk of data loss or mistakes while sharing multiple models, a common (software) platform is advised. Issues that emerged as a result of the cooperation should be noted and pursued.

During the coordination process, any discrepancies detected should be documented, handled, and reported to relevant model owners via coordination reports, which should include any particular locations of interferences and possible remedies.

After the problems found during the coordination exercise have been fixed, it is advised that an updated version of the model be frozen and signed-off. A digital signature might be used to provide protection.

22. COMMUNICATION & COLLABORATION IN BIM

The information flow in BIM can be considered as a web interconnecting different individual models and their information flowing freely towards and through each other at all times. This facilitates and ensures the availability of updated information to all parties.

This is achieved by following two elements:

h. Common Data Environment

Common data environment functions as an online or digital information repository that collects, manages and shares information to all stakeholders in an organized manner. Information includes building information models, drawings, reports, and other project-related information. These are safe, cloud-based, and accessible via a web browser, avoiding the need for expensive computer hardware. Viewpoint's '4BIM' web application, for example, allows collaborative collaboration using open-standard (IFC-based) data.

The data from a Common data environment is organized as different workspace. This in turn helps in immediate and easy access and movement of data among different stakeholders. Generally, a CDE that shares modeling data is structured as follows:

- Ongoing work: for information being currently produced and unverified data (one space per team)
- Shared: for information shared between several design/construction teams who will use it to coordinate their work (e.g. coordination of models and clash detection) and as a starting point on which to base subsequent work (e.g. sharing the architecture model as a basis for the structure model). In this area, the BIM Manager is able to examine and validate the information's compliance with the project BEP.
- Published: the information validated by the BIM Manager is accessible to all the other stakeholders. It is used to generate the project's deliverables (e.g. models, plans, and other submission documents).
- Archiving: Once data is no longer being used it is archived, but remains available.

i. Collaboration Through Physical Meetings

The other mode of information sharing is through physical meetings. For this further two strategies should be considered.

First, it is preferred that the project BIM team share a physical working space, a room or a hall for the collaborative working of different BIM working individuals. Secondly, the Project BIM Team should not depend only on information sharing to communicate about the project. Regular BIM coordination meetings should be scheduled by the Project BIM Team, during which team members gather to address design and construction challenges while utilizing the model as a shared resource. The frequency of these contacts is determined by the project's objectives, BIM Uses, and Project BIM Team members' competencies, and should be noted in the project execution plan.

The Project BIM Team should agree on how and in what manner the Project BIM Team members will collaborate using BIM throughout the BIM project planning process. A project specific BIM Execution Plan should be developed and agreed upon by all project stakeholders participating in modelling. The needs for information transmission between the parties, as well as anticipated interactions with the model, should be included in this strategy.

23. FILE NAMING CONVENTIONS

For discipline specific model coordination, all Project central files and model files must follow the name standard defined by the primary design company. This work will be coordinated by the Design Team BIM Manager with all sub-consultants and design disciplines.

The Design Team BIM Manager will develop a uniform naming standard for model views. The automated sorting of views for ease of identification is enabled by consistent view name. As project circumstances vary during the project, the protocol

allows for little maintenance of the view name. Template for filing conventions instructions is given in Annexure-C.

24. PRESENTATION STYLES

It is not uncommon for client organizations to have a specific format for model representation. Some client organizations such as Hong Kong sanitation department go as far as to mention the style and color of each mode element to be represented in the BIM Model. It is best to mention these requirements in the Project BIM Brief or modeling guidelines. This portion is usually described in BIM project brief(Annexure-A).

Once these are streamlined with every element having a unique style, it becomes much easier for all parties involved when working in a multidisciplinary federated model.

25. HARDWARE SOFTWARE REQUIREMENTS

All BIM project participants must have their own software licenses and PCs that can run the relevant software in order to do their tasks. Commercially available software that enables interoperability across the various software programs utilized within a project should be adopted by the Design Team. In the BIM Execution Plan, the program and version utilized must be specified. Furthermore, all project participants must have a network and Wi-Fi connection, allowing for remote project participation through webinars and model review sessions. If at all feasible, projects should stay on the same software version for the duration of the project. A project milestone should be used to discuss updates to a new software release. The Design Team will exchange BIM-related data via a common project portal that will be administered by the Design Team. To achieve excellent project delivery, design companies must execute internal collaboration across disciplines.

A number of BIM vendors exist, each offering their set of software and eco-systems with their own unique benefits. It is pertinent to mention which software is being used for which purpose at the beginning of the project in Project BIM Brief if Open BIM is not supported. However, the minimum recommended Hardware requirements for these advanced software are as follows:

- Windows 10
- 32 GB of RAM
- i7 Processor or better
- Dedicated graphics card with at least 2 GB of RAM
- 1 TB hard drive
- Dual screen set up (preferable 22” or bigger)

26. FACILITIES / ASSET MANAGEMENT

The Handbook's goal for this version was not to give a complete reference to improved Facilities Management (FM) and Asset Management (AM). The operating phase of the building, on the other hand, has the highest total expenses and provides the most opportunities for improvement.

The contractors' As-Built/Record Models, which are created at the end of the project, include a vast quantity of data. The FM/AM team should participate in the development of the Project BIM Brief and assess the Project BIM Execution Plan. The project's design phase is heavily focused on graphics. While including the attribute structure into the design models can increase the overall efficiency of data transmission to FM/AM, it is critical to ensure that the As-Built or handover models are appropriately prepared. COBie system best serves the information transfer and use. The information provided should be:

- focused on the data required to maintain the facility
- consistently formatted to facilitate direct or simple translation into the client's FM/AM systems
- contain any design information relevant to FM/AM to offer the greatest advantage for continuing FM/AM.

27. INFRASTRUCTURE/ HORIZONTAL CONSTRUCTION IN BIM

Building Information Modeling, as evident from the name, is attributed and commonly interpreted and used in building or vertical projects. However, the core competencies required for BIM science to be used on infrastructure or horizontal construction project is already present. A wide range of BIM Handbooks such as the Guide issued by Massachusetts Port Authority, Germany infrastructure BIM Guide, and Finland Road and Bridges guide affirm the positive role BIM is playing in the infrastructure and Horizontal Projects.

Infrastructure networks are treated as a single entity. Across their networks, clients often adopt comparable data and information standards and practices. Infrastructure and network descriptions, improvement renewal and maintenance activities, infrastructure condition, service performance, demand, and pertinent information are all examples of information required for life cycle asset management.

A network's information needs are enormous, and each activity, such as a capital improvement project or maintenance work, uses a fraction of the total information requirements. New information must be added to the client's information system as a result of work initiatives or programs. The contents of this followed in step sequence can also ensure the usage of BIM in horizontal or infrastructure projects with nuanced modifications.

ANNEXURE-A - PORJECT BIM BRIEF (EIR) Template

Project BIM brief is the first document that should be created in the initial stages of the BIM project. This is the first step toward project management through BIM. This document contains information regarding specific goals the client needs to be fulfilled through the implementation of BIM.

In this document, the client outlines the specific goals and objectives that they wish to achieve through the successful implementation of BIM. Each goal can be attributed to a specific BIM use. This document forms the basis for the BIM execution plan.

It manages the expectations from a contractor by outlining in sufficient detail the requirements of a specific project or the goals a parent organization is generally working towards achieving.

PROJECT INFORMATION:

This portion gives basic information regarding this document.

Prepared By:	
Organization Name:	
Administered By:	
Date of Preparation:	
Addendum:	

ADDENDUM RECORD

This document can be used as an Request for proposal. Any additions or subtractions from the original documents should updated here.

Revision No.	Date of Revision	Revision Area	Revised By:	Comments

BASIC PROJECT INFORMATION:

Project Name:	
Client Organization:	
Source of Funds:	
Project Location:	
Project Type	
Contract Type/ Delivery Method	
Construction Start Date	

STANDARDS

Any specific international or national standards that should be followed implementation of BIM.

Sr. No.	**BIM Standards Applicable For This Project**

SOFTWARE REQUIREMENTS & INFORMATION EXCHANGE

It is prerogative of the client organization to advise the use of any specific modeling software and the formats in which the exchange of information and models is expected to happen.

BIM Use	**Software / Tool**	**Information Exchange Requirement**	**Frequency / Schedule**
Use	*Required Software*	*File Format Required*	

PROJECT TIMELINE

In accordance with the estimated project timeline, milestones should be set for the contractor to plan the process accordingly.

Project Phase /Milestone	**Completion Date**	**Remarks**
Project Establishment		
Conceptual Design Phase		
Initial Cost Estimation		
Approval of Project		
Detailed Design		
Procurement		
Construction Phase		
Handing Over		

Operation and Maintenance		

PROJECT FOCAL PERSONS

Role	Discipline	Organization	Name	Contact Details
Client Rep.				
Consultant Person				
Other roles				

PROJECT BIM GOALS

Project BIM goals are set by the client in order to better communicate the needs and wants of the project related to BIM that help translate Project BIM Deliverables.

Goal	Priority	BIM Use	Remarks
	(high/med/low)		

BIM DELIVERABLES

These are the client requirements through the application of BIM process in the project lifecycle. These define the end results that the contractor is expected to provide.

Milestone	Deliverable	Due Date	FORMAT	Remarks

BIM ORGANIZATIONAL STRUCTURE

Contractor is expected to provide the list of BIM qualified personnel to help client better gauge the ability of the contractor in implementation of BIM.

ROLE	NAME	QUALIFICATION	YEARS OF BIM EXPERIENCE	RESPONSIBILITIES

PREVIOUS BIM PROJECTS

List down the previous project the contractor has completed using BIM.

PROJECT NAME	LEVEL OF BIM USE	DESCRIPTION

ANNEXURE-B - BIM EXECUTION PLAN Template

This is the most important document for a project's BIM implementation. It's an extension of the Project BIM Brief, and it's created collectively by the project executing team after they've been hired. It's a living document that may be modified as the design and construction stages progress. It goes through each of the client's objectives and how they will be met. The Project BIM Execution Plan assigns essential roles and specifies the processes, procedures, and tools to be utilized in the project.

BIM EXECUTION PLAN INFORMATION:

Prepared By:	
Organization Name:	
Administered By:	
Date of Preparation:	
No. Of Revisions:	

REVISION RECORD

Since this is a living document, changes can be made to this documentation with approval of stakeholders. It is important to keep track of all the changes that have been made affecting the deliverables of the BIM process.

Revision No.	Date of Revision	Revision Area	Revised By:	Comments

BASIC PROJECT INFORMATION:

Project Name:	
Client Organization:	
Project Location:	
Project Type	
Contract Type/ Delivery Method	
Construction Start Date	

STANDARDS

This section is for listing down the standards followed during the modeling process and BIM implementation. Any local, national and international standards followed should be mentioned below.

Sr. No.	**BIM Standards Applicable For This Project**

SOFTWARE REQUIREMENTS & INFORMATION EXCHANGE

BIM Use	**Software / Tool**	**Information Exchange Requirement**	**Frequency / Schedule**
Cost Estimation	*Required Software*	*File Format Required*	
Other Uses			

PROJECT SCHEDULE

Project Phase /Milestone	**Estimated Start Date**	**Completion Date**	**Remarks**
Project Establishment			
Conceptual Design Phase			
Initial Cost Estimation			
Approval of Project			
Detailed Design			
Procurement			
Construction Phase			
Handing Over			
Operation and Maintenance			

PROJECT FOCAL PERSONS

Role	Discipline	Organization	Name	Contact Details
Client Rep.				
Project Manager				
BIM Manager				
BIM Designer				
BIM Coordinator				
Other roles				

PROJECT BIM GOALS

Goal	Priority	BIM Use	Remarks
	(high/med/low)		

BIM ROLES & RESPONSIBILITIES

Title	Organization	Responsibilities
BIM Designer	*Design Consultant*	*Authoring Model Design Elements and Clash Detection*

COORDINATION AND COMMUNICATION

Project coordination methodology should be mentioned in advance to ensure the collaboration procedure as per the requirement of the client and for better quality control purposes, keeping all stakeholders in loop.

Interdisciplinary Meetings			**Frequency:**	
Agenda / Issue	Attendees	Discussion	Remarks / Actions	Action By

Project Team Meetings			**Frequency:**	
Agenda / Issue	Attendees	Discussion	Remarks / Actions	Action By

QUALITY CONTROL CHECKS

The respective BIM coordinator of each discipline should also establish a quality control procedure to ensure that the discipline model is accurate and correct according to the modelling guidelines.

Quality Check	Description	Responsibility	Project Stage	Frequency

ANNEXURE - C - BIM Documentation Practice Template

For discipline specific model coordination, all Project central files and model files must follow the name standard defined by the primary design company. This work will be coordinated by the Design Team BIM Manager with all sub-consultants and design disciplines.

FILING SYSTEM

TRADE	CODE	SUB-CATEGORY	CODE	FILE NAME	USE	CREATED BY	LAST MODIFIED	FILE FORMAT

ANNEXURE - D - BIM LOD (Level of Detail) - US Template

Preface:

The Level of Detail (LOD) scale is used to indicate the consistency of material that should be supplied for certain model components at various stages of model development. When LOD is used the major goal is to define what each member of a design/construction team is responsible for authoring in their models at each step, and to what degree others may depend on them. At any step of delivery, project models will usually include aspects from previous stages of development.

Levels of Detail:

LOD100	LOD200	LOD300	LOD350	LOD400	LOD500
The Model Element may be visually represented in the Model using a symbol or other generic representation, however this does not meet the LOD 200 criteria. Information about the Model Element (such as cost per square metre, HVAC tonnage, and so on) may be extracted from other Model Elements.	The Model Element is a generic system, item, or assembly with approximate amounts, size, form, position, and orientation that is visually represented inside the Model. The Model Element may also have non-graphic data associated to it.	Within the Model, the Model Element is visually represented as a particular system, item, or assembly in terms of number, size, form, position, and orientation. The Model Element may also have non-graphic data associated to it.	The Model Element is a particular system, item, or assembly that is visually represented inside the Model in terms of number, size, form, placement, orientation, and interactions with other building systems. The Model Element may also have non-graphic data associated to it.	The Model Element is a particular system, item, or assembly that is visually represented inside the Model in terms of size, shape, position, number, and orientation, as well as detailing, fabrication, assembly, and installation information. The Model Element may also have non-graphic data associated to it.	For maintenance and operations, elements are represented as formed assemblies. Non-geometric information is linked to modelled components in addition to real and exact size, shape, position, amount, and orientation.

Following are the attributes for each level of detail. Although these are the standards set for general universal use, these can be modified at the start of the project for an

individual project as per your needs. While modeling each reference to the level of detail should incorporate following attributes.

LOD-100	
Conceptual Design	Non-geometric lines, areas or volume zones
Scheduling	Total Project Construction duration
Cost Estimation	Conceptual cost estimation
Energy Analysis	Strategy and performance criteria based on volumes and areas
Milestones	Outline Planning Permission and Project feasibility

LOD-200	
Conceptual Design	Three dimension-generic elements
Scheduling	Time-scaled, ordered appearance of major activities
Cost Estimation	Estimated cost based on measurement of generic element
Energy Analysis	Conceptual design based on geometry and assumed system types
Milestones	Planning Approval and Design & Build Tender Documentation

LOD-300	
Conceptual Design	Specific elements with dimensions, capacities and space relationships
Scheduling	Time scaled ordered appearance of detailed assemblies
Cost Estimation	Estimated cost based on measurement of specific assembly
Energy Analysis	Approximate simulation
Milestones	Building Plan Approval, Continued Design & Build Tender Documentation or Design-Bid- Build Tender Documentation

LOD-400	
Conceptual Design	Shop Drawing/fabrication with manufacture, installation and other specified information
Scheduling	Fabrication and assembly detail including construction means and methods
Cost Estimation	Committed purchase price of specific assembly at buyout
Energy Analysis	Precise simulation based on specific information
Milestones	Constructability and Fabrication

LOD-500	
Conceptual Design	As-Built
Scheduling	N/A

Cost Estimation	As-built
Energy Analysis	Commissioning and recording of measured performance
Milestones	Final Completion

For use of this information system, it is advised that the project team set up their own standard to the LOD and LOI required at each stage. Also, this document must be read in conjunction with the modeling guidelines.

Project Stage	Model Element	Level of Detail
Conceptual Stage		*LOD 100*
Pre Design Stage		
Detail Design Stage		
Construction Stage		
Handing over		

Tolerance:

It is paramount to mention the allowable tolerance in the given model element at the beginning of the project. This also forms the basis of checks to be performed on each model element.

Stage	Discipline	Tolerance
Conceptual Stage	*Civil, Architectural etc.*	*Accurate to +/- 10 MM of Actual Size*
Pre Design Stage		
Detail Design Stage		
Construction Stage		
Handing over		

BIM LOI (Level of Information)- UK Template

Level of Information:

"Level of Information is defined as the amount of detail contained within the non-visual parts of a model – The Data"

The system is primarily used in UK and some parts of EU. The concept of this LOD is primarily the same but with minute differences. This is focused on both the geometry and the structured data, and acknowledges that the balance between them vary across the lifecycle of the model element.

- LOI -1– Brief – Project information is discussed
- LOI -2 – Conceptual Stage – In this stage the particulars of the project are defined and discussed and discusses the uses as well as limits of the project

- LOI -3 –Definition - Generic geometric representation of element. Specification properties and attributes to allow selection of manufacturer product

- LOI -4–Design - Here we have a 3D representation with specification attached. The geometric detail should be minimum space allocation for operational and maintenance space

- LOI -5– Build and commission - Replace generic product with product procured from manufacturer. Reattach/ relink object to replacement object. Should also include final positioning of pipework and ductwork.

- LOI -6– Handover and closeout - All necessary information about the product should be included - operations and maintenance documentation - The model should now be a "digital twin" - as constructed.

- LOI -7– Operational and in use - Update asset information model with maintenance records, replacement dates, replaced equipment.

Project Stage	**Model Element**	**LOI**
Conceptual Stage		*Information required to support LOD*
Pre Design Stage		
Detail Design Stage		
Construction Stage		
Handing over		

Stage	**Discipline**	**Tolerance**
Conceptual Stage	*Civil, Architectural etc.*	*Accurate to +/- 10 MM of Actual Size*
Pre Design Stage		
Detail Design Stage		
Construction Stage		
Handing over		

ANNEXURE - E - BIM MODELING GUIDELINES Template

Preface:

BIM Modeling guidelines should be read in conjunction with the BIM Project brief. The project BIM Brief gives an insight into the requirements of the client and his needs. Depending on the requirement of the client, this document could either be a part of the client's BIM Project Brief or the Project BIM Execution Plan submitted by the client. In both cases, this document provides detailed instructions or explanation, depending upon the case, regarding the modeling practices and standards set and used in modeling process throughout the project life cycle.

OVERVIEW

All modelling practices should be in sufficient detail which should be agreed upon at the inception of the project. It is good practice to formalize the standards and processes through which the project should be modeled.

It is a good practice to define each process, its use and the methodology through which modeling is done. The modeling process should be divided into separate functional sub-parts based on the specialized area of the project i.e. Architectural, Structural, MEP etc. It is further advised to define further uses and benefits of each process at a specific stage.

Stages vs Disciplines	**Architectural Design**	**Structural Design**	**MEP Design**	**Intended Use**
Conceptual Stage				
Design Phase				
Construction Phase				
Handing Over				

Architectural/ Structural/ MEP BIM Modeling:

Once an overview and general uses of the BIM Modeling process are established. The uses are further divided into functional aspects of each process and set guidelines should be mentioned serving as the complete modeling guidelines for element of a functional aspect of a model.

Stage	Elements	Modeling Guidelines	Remarks
Conceptual			
Pre Design			
Detailed Design			
Construction			
Handing Over			

Quality Assurance

After the modeling process has started, it is natural that some process may be overlooked as compared to others. To cater safe guard model elements from any neglect and discrepancies, systematic and periodic checks should be established.

Design Category	Stage	Quality Check	Remarks

Software Use:

Stage	Model Element	Use	Software	Remarks

Color Codes:

It is common practice for parent organizations to provide specific guidelines regarding elements of projects. For example, plumbing line are to be modeled in color grey with specifc color code.

Model Element	Use	Color Code	Color

Base Units:

Setting units for measurement for a specific project.

Description	**Unit**	**Symbol**
Length	*Millimeter*	*MM*

ANNEXURE - F - BIM ROLES AND RESONSIBILITY MATRIX
Template

Preface:

BIM roles and responsibilities hugely depend on the client organization and the project delivery method. In each case a new of roles and responsibilities matrix needs to be prepared and assigned in the BIM execution plan. For case of Pakistan, in DBB and DB projects, two new specialists, known as BIM Managers for Projects and BIM Coordinators for Consultants and Contractors, have been designated in Annexure R to help with BIM procedures.

BIM Roles

BIM Roles	Responsibilities
Project BIM Manager (This role can be played by the lead consultant or BIM specialist appointed by the employer or project manager)	Facilitate the definition and implementation of: • BIM Execution Plan • BIM Goal and Uses • Responsibility Matrix • BIM Deliverables • Delivery Schedules • BIM Modelling Quality Control • BIM Coordination
BIM Coordinator for Consultant	At Design and Construction Stage • Create BIM Design Models and Documentation • Define discipline-specific BIM uses including analysis • Coordinate between BIM modellers, design consultants and cost consultant • Coordinate with contractor and subcontractors • Ensure Modelling Quality Control
BIM Coordinator for Contractor	At Construction Stage • Coordinate with design consultants and subcontractors • Study tender documents • Review Design Models and Fabrication Models and Drawings • Use BIM for coordination, sequencing, constructability and cost studies, and field use • Create construction and as built models

	• Ensure Modelling Quality Control

It is further advised to break down each Coordinator's structure and define the duties, roles, responsibilities, and jurisdiction of each modeling professional involved in the BIM Modeling process.

BIM Role	Name	Responsibility	Remarks
Consultant BIM Coordinator			
BIM Modeler			
Information Manager			

Following is perhaps the most important part of the BIM planning and execution process. One all the roles and responsibilities of each project member have been assigned, each member should be assigned a specific duty at a specific stage of the project.

BIM Process		Conceptual Stage	Pre Design	Detailed Design	Construction Phase	Handing Over Phase
BIM Role	Organization					

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