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Mapping of Civil Engineering Research Output at IIT Bombay during 2006-2016

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Abstract

Purpose: This paper evaluates research output of Department of Civil Engineering, IIT Bombay for the period 2006-2016. An analysis of 734 documents pertaining to IIT Bombay as reflected in Scopus Database has been made based on Scientometric principles . This study aims to find out year wise growth of publications, cumulative growth and annual growth rate, types of documents, preferred source for publication and degree of collaboration.

Methodology: Documents that are indexed in Scopus database have been selected for this study. IIT Bombay has been used as a keyword for all fields. Refine option was used to limit the publication year to 2006-2016 and subjects as "Civil Engineering". Erratum and letters are not considered for the study. Spreadsheet is used for analysis of data.

Findings: Analysis of the data used for this study indicates that the year 2016 has been most productive year. Out of 734 publications majority are journal articles followed by conference papers. An oscillating trend of publication growth has been recorded. Highest degree of collaboration was recorded as 0.98 in the year 2013 with a mean value of 0.95 for 11 years. Collaborative research culture is evident since highest numbers of publications are of two authors followed by three authors. Prolific authors during the period of study were: R.S. Jangid (at top) followed by D. Choudhury, D.N. Singh, T. Kant, T.I. Eldho, V. Jothiprakash, D. Singh, S. Ghosh, T.V. Mathew, M.C. Deo, Y.M. Desai and B.V.S. Viswanadham. Among the list of preferred source for publication, Geotechnical Special Publication is the highly preferred one with highest number of publications appeared in it. Less number of publications has appeared in journals that are having impact factor ≥4. International level publications are preferred

over national ones.

Originality/Value: This is an original research work as no published work has been traced on this topic so far to the best of our knowledge and reach. Findings of this study are presumed to provide valuable description on civil engineering research performance of IIT Bombay.

Keywords: Scientometrics, Research Productivity, Research Performance, Publication productivity, Civil Engineering, IIT Bombay

1. Introduction:

Civil Engineering is one amongst the core branch of engineering that deals with design construction and maintenance of the physical and naturally built environment including public works such as roads bridges, canals, airports, sewerage systems, pipelines, structural components of buildings and railways[20]. IIT (Indian Institute of Technology) Bombay was established in the year1958 and the Civil Engineering Department is part of the institute since its inception. The Department has grown tremendously over the years and is now recognized as one of the major engineering departments in the country. The department has developed strong links with the building and construction industry and academic and research, both within and outside the country. Besides high quality teaching and instruction at both UG and PG levels, the Department is actively involved in basic and applied research and consultancy and provides high quality technical advisory support through various R&D projects and consultancy to various organizations. The Department of Civil Engineering with its multifaceted faculty continues to maintain and cultivate its strong links with the infrastructural industry and academic and research institutions both within and outside the country[19]. Therefore it is imperative to measure the research output carried out by this department. This paper

aims to evaluate the Civil Engineering research output of IIT Bombay for the period 2006-2016 as reflected in Scopus database by identifying year wise productivity, types of publications, journals preferred, research areas, authorship pattern, etc.

2. Review of Literature:

The authors have made a thorough review of Literature and found several scientometrics studies on different areas but only a few and relevant ones has been reviewed here for this present work.

Kademani and others (2006)[17] undertaken a Scientometric study on Publication Productivity of the Analytical Chemistry Division at Bhabha Atomic Research Centre. Analyses of 724 papers has been done to quantify the publication behavior of scientists during 1972-2003. Publications brought out by the Chemistry division, BARC Annual Reports and Progress Report of Analytic Chemistry Division are the basis of data for this study.

Kademani and others (2007)[16] have performed a Scientometric study on Publication Productivity of the Radiochemistry Division At Bhabha Atomic Research Centre. Analysis of 1044 papers published by the scientists of Radiochemistry Division at Bhabha Atomic Research Centre (BARC) during 1958-2005 in diverse domains was evaluated for year wise productivity, authorship pattern and collaboration.

Sevukan and Sharma (2008)[15] did research performance analysis of biotechnology faculties in central universities of India for the period 1997-2006 using PubMed and ISI Web of Science database, Science Citation Index Expanded (SCIE). They found that the growth of literature in biotechnology has steadily increased and two-authored publications are prevalent. Applicability of Lotka's law is also been validated.

Nandi and Bandopadhyay (2013)[14] in a study on "Scientometric Dimensions of Research Productivity of the Botany Department, During 1960-2000" analysed 160 theses and 739 thesis articles collected from the Botany Department of University of Burdwan in eight subdivisions of Botany during 1960-2000 to determine year wise productivity, authorship pattern and collaboration.

Barik and Jena (2014)[13] conducted a study on "Growth of LIS Research Articles in India seen through Scopus: A bibliometric analysis" to analyze the growth of Library and Information Science (LIS) research articles in India. 385 articles indexed by Scopus database during the period of 2004-2013 has been considered for the study and the authors have analyzed the annual growth of LIS research publications in India and to identify the authorship pattern, authors' productivity and degree of collaboration. Lotka's inverse square law has been applied to identify the productivity of authors and Bradford's law has been applied to identify the scattering of core journals.

Abramo and Angelo (2014)[12] in their paper "How do you define and measure research productivity" have operationalized the economic concept of productivity for the specific context of research activity and show the limits of the commonly accepted definition. A measurable form of research productivity through the indicator ''Fractional Scientific Strength (FSS)'' has been proposed in view of the microeconomic theory of production.

Khanna and others (2017)[10] have conducted a "Scientometric Analysis of the Research Output of Department of Physics and Astronomy of Guru Nanak Dev University during 2006-15" to analyze research contributions with the use of Scopus. They have examined year-wise research productivity, national and international collaborations, top collaborating institutions, most prolific authors, journals used for communication, most preferred journals for publication, number of citations received by the University during

the period undertaken for study. This study indicates that journals are the most preferred form of publication to communicate research works by the researchers.

Pradhan and Ramesh (2017) [11] in their study on "Scientometrics of Engineering Research at Indian Institute of Technology Madras and Bombay during 2006-2015" assessed 5378 papers published by Indian Institute of Technology Madras and 4430 papers published by Indian Institute of Technology Bombay respectively indexed by the Scopus database in the field of Engineering Sciences and its subfields. The study summarizes that the number of papers grew during the period of study.

Nandi and Mondal (2017)[9] performed a study on " Research Productivity in Department of Chemistry and Physiscs of Burdwan University. Comparative research performance of Chemistry and Physics department has been made by analyzing the awarded thesis and published articles that are reported in annual reports of the university. The duration of the study was 40 years (1960-2000).

Nagarkar and Kengar (2017)[5] have analyzed the research output of Physics Department of Savitribai Phule University for the period 1990 to 2014 as per the publication data available in SCOPUS database. They have examined year-wise productivity, types of publications, national, international, local collaborations, and active areas of research, preferred journals for communication and authorship pattern.

Mukherjee (2017)[8] evaluated the research output of CSIR laboratories with the help of publication output as recorded in Web of Science and Scopus. Findings of this study reveals that during 2010 to 2015, the growth rate is neither linear nor exponential. The scientists of the laboratory attach more weight to foreign journals rather than Indian journals having SCI impact factor within the range of 2.0 to 4.0. The authorship trend is completely slanted towards co-authorship and CSIR is assisting considerable financial

support for conducting research.

Banshal, Singh, Basu and Muhuri (2017)[7] analysed the research performance of 16 older IITs of India in order to identify productivity, productivity per capita, rate of growth of research output, authorship and collaboration pattern, citation impact and discipline-wise research strengths of the different IITs. The re- search performances of the IITs have been compared with those of two top ranking engineering and technology institutions of the world (MIT-USA and NTU-Singapore) and most cited papers from these IITs have also been identified.

Pradhan and Mohapatra (2017)[6] evaluated the growth of research work in the domain of social sciences and humanities in Odisha during the period 1996 to 2015 based on the publication output available in Scopus database. An assessment of year wise growth of publications, most productive authors, major subject areas of research, types of publications preferred by the researchers, preferred journals and the major productive institutions in the field of social science and humanities have been done.

Patel (2017)[4] have carried out a Scientometric analysis of publications of National Institute of Technology Kurukshetra during 2012 to 2016. Web of Science database has been used for data collection. Result of this study highlights growth of literature, preferred form of publication, top collaborating institution, highly productive subject areas , most favored countries for collaborations, prolific authors etc.

Kumar (2018)[3] evaluated the research performance of ARIES, Nainital on the basis of Web of Science (WoS) data during 2001-2015. Analysis of 574 research papers has been done to identify the active scientists, active areas of research, preferred journals, citations and h-index, collaborating institutions, countries and research funding agencies. Findings also indicate the publication pattern, degree of collaboration as well

as the nature of the research activities.

Banshal, Solanki, and Singh (2018)[2] have assessed the research performance of the National Institutes of Technology (NITs) in India during 2005–2016. Web of Science database was used to collect publication data. This study has identified productivity, productivity per capita, rate of growth of research, international collaboration pattern, citation impact and discipline-wise distribution of the research output for the NITs. The performance of NITs has also been compared with two top-performing Indian institutions, namely Indian Institute of Science, Bengaluru and Indian Institute of Technology Bombay, Mumbai.

3. Objectives:

This study aims to yield quantitative and qualitative analysis of the research performance of IIT Bombay in the field of Civil Engineering as reflected in its publications output and is reported in SCOPUS databases. The specific objectives set for the present study is:

a) To measure the year-wise growth and types of publication.
b) To determine cumulative growth and annual growth rate.
c) To study the authorship pattern.
d) To ascertain degree of collaboration.
e) To trace most prolific authors.
f) To identify journals preferred by faculty members, their country of origin and coverage.
g) To quantify the research output published in national and international indexed journals

4. Methodology: SCOPUS has been used for source of data collection. “IIT Bombay” has been used as a keyword in “all fields” to retrieve the records. The data was further refined to publication year as “2006-2016” and subjects as “Civil Engineering”. Found 738 records. Erratum and letters has been excluded, therefore, finally analysis of 734 documents has been made. Both bibliographical and citation data was noted in spreadsheet and analysis has been done after validation as per the objectives.

5. Scope and Coverage: Geographical scope of this study is limited to Department of Civil Engineering, IIT Bombay. Chronological scope is limited to 2006-2016. Publication type considered for the present study is articles published in journals, conference papers, reviews, book, book chapter, editorial and notes. Erratum and Letter has not been considered for analysis.

6. Analysis of Results:

6.1. Year-wise Growth of Publications and Types of Publication:

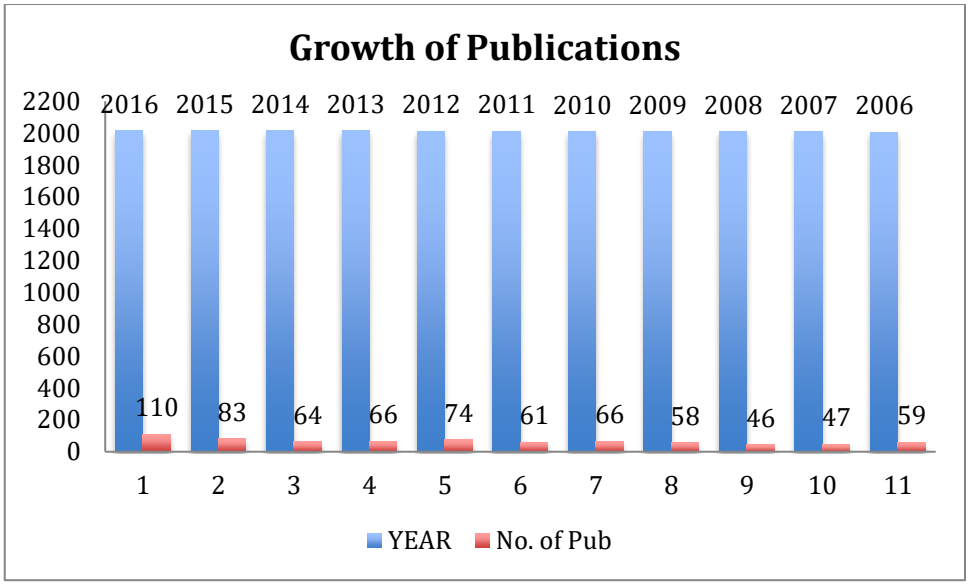
Selection of an appropriate form often has an influence on the visibility and impact of research. Hence, analyses of the types of document used for communicating research results are very important. Table-1 traces growth and publication types of Civil Engineering department during the period 2006-2016. During this span of eleven years a total of 734 publications has been published. The year 2016 has remained most productive year for the department with 110 publications, wherein journal articles are the major form of publication. The years 2007 and 2008 remained as less productive year with only 46-47 publication outputs. An upward trend has been seen during the 2009, 2010, 2012 and 2013. Downward trend has been seen during the year 2011,2008 and 2007. After 2013 there has been a steady growth of publications. It has also been observed that during the period of study journal articles has acquired major portion

74.38 % of the total publication output followed by conference papers 19.48%. Average number of publications per year was 66.72.

Table-1 Year wise growth of publication types :*(Objective-a)*

Year	Journal Article	Conference Paper	Review	Book	Book Chapter	Editorial	Note	Total
2016	76	26	1	3	4	0	0	110
2015	56	20	0	1	4	0	2	83
2014	45	13	3	2	0	1	0	64
2013	48	16	1	0	0	1	0	66
2012	51	18	3	2	0	0	0	74
2011	45	12	0	0	0	3	1	61
2010	52	14	0	0	0	0	0	66
2009	50	6	0	1	1	0	0	58
2008	35	7	0	1	1	0	2	46
2007	45	1	1	0	0	0	0	47
2006	43	10	4	0	0	1	1	59
Total	546	143	13	10	10	6	6	734
%	74.38	19.48	1.77	1.36	1.36	0.81	0.81	99.97
Average	66.72							

Graph-1



6.2 Cumulative Growths and Annual Growth Rate of Publications:

Table-2 depicts cumulative growth and annual growth rate of publications during the period of study. During the period 2006-2016, department of Civil Engineering has published a total of 734 publications. Highest number of publication is 110 that is published in the year 2016 and lowest number of publication is 46 published in the year 2008. Table-2 also reflects Annual growth rate of total publications and is evident that there is an oscillating trend of growth. The AGR has been decreased to -20.33 in 2007 and -2.12 in 2008 and it was increased to 26.08 in 2009. Since then, there is oscillation in every 2 to 1 year period as illustrated in table 2. The reason for this variation is that there is no constant growth of publications in every year.

The Cumulative Annual Growth Rate (CAGR) and Annual Growth Rate (AGR) has been calculated as per the following method:

CAGR/AGR= (EV-FV)÷FV× 100

EV=End value

FV=First Value

Table-2 CAGR and AGR of publications:*(Objective -b)*

Year	Documents	Percentage	Cumulative Total Growth	Cumulative Growth Rate(CAGR) Percentage (%)	Annual Growth Rate (AGR)
2016	110	29.4	734	100	32.53
2015	83	11.3	624	85.01	29.68
2014	64	8.7	541	73.70	-3.03
2013	66	8.9	477	64.9	-10.81
2012	74	10.08	411	55.9	21.31
2011	61	8.31	337	45.9	-7.57
2010	66	8.9	276	37.6	13.79
2009	58	7.9	210	28.61	26.08
2008	46	6.2	152	20.70	-2.12
2007	47	6.4	106	14.4	-20.33
2006	59	8.03	-	-	
Total	734				

6.3 Authorship Pattern:

Table-3 and Graph-3 outlines authorship pattern of the publications. It is seen that publications with two authors are more prevalent which is 48.77%. On the contrary only 3.81 % of papers are with single authors. It is evident from the table and graph that collaborative research culture is pragmatic in the department of Civil Engineering, IIT Bombay during the period of study.

P = $(NP \div TP) \times 100$

P=Percentage

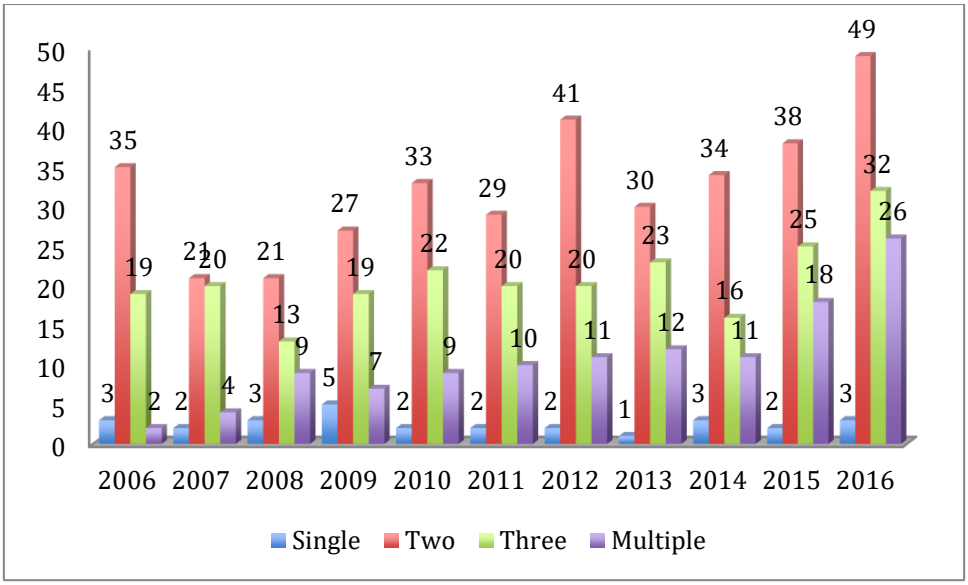
NP = Number of publications

TP = Total Publications

Table-3Authorship Pattern:*(Objective-c)*

Authorship	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**Total**	P
Single	3	2	3	5	2	2	2	1	3	2	3	28	3.81
Two	35	21	21	27	33	29	41	30	34	38	49	358	48.77
Three	19	20	13	19	22	20	20	23	16	25	32	229	40.47
Multiple	2	4	9	7	9	10	11	12	11	18	26	119	16.21
Total	59	47	46	58	66	61	74	66	64	83	110	734	

Graph-3 Authorship Pattern



6.4 Degree of Collaboration:

Degree of collaboration is essential to study the potency of Co-authorship pattern. Co-authorship is type of collaboration in which two or more authors share their ideas and resources to write a paper. Degree of collaboration has been calculated with the help of Subramanyam's formula[18] and is reflected in Table-3. The degree of collaboration "DC" indicates that collaborative publications are more prominent than that of publications with single authors.

Degree of collaboration over the period of study is steadily rising and ranged between 0.93-0.98. The year 2013 is recorded as the most productive year for highest degree of collaboration, which is 0.98% and the mean value is 0.95.

$$DC = \frac{N_M}{N_M + N_S}$$

Here,

DC = Degree of Collaboration

N_M = Number of publications with multiple authors

N_S = Number of publications with single author

Table-4 Degree of Collaboration:*(Objective-d)*

Year	**(N_S)**	**(N_M)**	**$N_M + N_S$**	**Degree of Collaboration**
2006	3	56	59	0.94
2007	2	45	47	0.95
2008	3	43	46	0.93
2009	5	53	56	0.94
2010	2	64	66	0.96
2011	2	59	61	0.96
2012	2	72	74	0.97
2013	1	65	66	0.98
2014	3	61	64	0.95
2015	2	81	83	0.97
2016	3	107	110	0.97
Total	28	706	732	Mean=0.95

6.5 Prolific Authors:

Table-5 indicates top ten most prolific authors of the department for the period of study in terms of number of publications. Equal weightage was given to each author and total count method is followed to find out top 10 most prolific authors. The analysis of the Table-5 states that out of 734 publications, R.S Jangid is the most prolific author with highest number of publications to his credit.

Table-5 Prolific Authors:*(Objective-e)*

Rank	Author Name	NP=734	Percentage
1	R.S. Jangid	71	**9.62**
2	D. Choudhury	57	**7.72**
3	D.N. Singh	50	**6.77**
4	T. Kant	38	**5.14**
5	T.I.Eldho	33	**4.47**
6	V. Jothiprakash	30	**4.06**
7	D. Singh	29	**3.92**
8	S. Ghosh	24	**3.25**
8	T.V. Mathew	24	**3.25**
9	M.C. Deo	22	**2.981**
10	Y.M. Desai	21	**2.84**
10	B.V.S. Viwanadham,	21	**2.84**

6.6 Preferred Journals:

It is rendered from the Table-6 that the Geotechnical Special Publication has remained high choice of the scholars with highest number of publications appeared in it. It is characterized a Conference Proceeding. ISH Journal of Hydraulic Engineering is the Second Choice. It is also observed that top 3 most preferred journals have no impact

factor or very less impact factor. Less number of publications have appeared in journals that are having impact factor ≥4. It is also interesting to record that the scholars prefer to publish their research in the publications that are categorized as international.

Table-6 Preferred Journals: *(Objective-f & g)*

Rank	**Source Title**	**PT***	**Coverage**	**Country of Origin**	**Publisher**	**NP#**	**IF^**
1	Geotechnical Special Publication	CP*	International	United States		56	
2	ISH Journal Of Hydraulic Engineering	Journal*	International	Pune, Indian Society for Hydraulics	Taylor & Francis	35	
3	Geotechnical And Geological Engineering	Journal*	International	Switzerland	Springer	19	
3	Water Resources Management	Journal*	International	European Water Resources Association (EWRA) Greece	Springer	19	
4	Journal of	Journal	International	USA	ASCE (American	1	4.

	Hydrologic	ur	rnat		Society for Civil	6	1
	Engineering	na	iona		Engineers)		0
		l	l				1
		Jo					4.
		ur					1
	Composite	na				1	0
5	Structures	l	International		Elsevier	4	1
		Jo	Inte				
		ur	rnat				
		na	iona		World Research	1	
5	Disaster Advances	l	l	Indore, India	Journals	4	
		Jo	Inte		ASTM (American		0.
		ur	rnat		Society for		6
	Journal Of Testing	na	iona		Testing and	1	6
6	And Evaluation	l	l	USA	Materials)	3	9
		Jo	Inte				0.
		ur	rnat				6
	Transportation	na	iona			1	9
7	Research Record	l	l	Washington, USA	Sage	2	5
		Jo	Inte				3.
		ur	rnat				4
	Construction And	na	iona			1	8
8	Building Materials	l	l	USA	Elsevier	0	5
	Civil Comp	C	Inte				
9	Proceedings	P	rnat	UK	Civil-Comp Press	9	

		*	iona l				
	International Journal Of Earth Sciences And	Jo ur na	Inte rnat iona		Cafet Innova		0. 0 4
9	Engineering	l	l	Hyderabad, India	Technical Society	9	2
	International Journal Of Advanced Structural	Jo ur na	Inte rnat iona	Islamic Azad University, South			
10	Engineering	l	l	Tehran	Springer	8	
		Jo ur na	Inte rnat iona				2. 9 6
10	Smart Materials And Structures	l	l	Bristole, USA	IOP Publishing	8	3

*CP=Conference Proceedings

*PT=Publication Type

#NP=Number of Publications

^IF=Impact Factor

7. Findings and Conclusion:

The scholars from the department of Civil Engineering, IIT Bombay preferred to publish their research in journals. The year 2016 has been most productive year with highest number of publications. There is an oscillating trend of publication growth and clear evidence of collaborative research culture. Prof. R.S. Jangid has appeared as most

prolific author with highest number of publications to his credit during the period of study.Geotechnical Special Publication is reflected as most favorable of the scholars with highest number of publications appeared in it. Less number of publications has appeared in journals that are having impact factor ≥4. It is also interesting to record that the scholars prefer to publish their research in the international publications.