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Research Article

Dr Gangan Prathap's Contribution in Non-linear Structural and Computational Mechanics Research: A Bio-bibliometric Study during 1975-2010

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ABSTRACT

Dr Gangan Prathap made a pioneering contribution to research in non-linear structural and computational mechanics. This study presents a bio-bibliometric analysis to quantitatively and qualitatively assess his lifelong scholarly contributions, publication trends, and research impact, based on his 126 Scopus-indexed publications published during 1975-2010 in non-linear structural and computational mechanics. Relevant publications by Dr Prathap were identified and retrieved from the Scopus database during 1975-2010 on this topic. Several well-known bibliometric indicators were used to analyse publication growth, citation distribution and citation impact, pattern of authorship, extent and nature of collaboration, significant keywords, media of communication and characteristics of high-cited papers. The analyses used Biblioshiny and VOSviewer software for detailed analysis. The study findings reveal that his 126 publications received 2514 citations, averaging 19.95 citations per paper. His annual productivity showed an increased and decreasing trend, peaking at 15 publications in 1976. Dr Prathap collaborated extensively with 10 national institutions and 43 authors in these 126 publications, demonstrating a highly collaborative research approach. Among his 126 publications, 85 publications involve intra-departmental, 34 national collaborative and 6 international collaboratives. Publications were distributed across 28 journals, with the International Journal of Computational Methods in Engineering (26 papers) and Computers and Structures (25 papers) emerging as the most productive sources. The top 20 High-Cited Papers (HCPs) account for 15.87% and 56.92% share of his total publications and citations. Dr Prathap's research output demonstrates a strong fluctuating trend in output, strong citation impact, extensive collaboration, and strong involvement in few priority scientific areas. The findings highlight Dr Prathap's profound legacy in shaping the non-linear structural and computational mechanics research field, while evaluating his academic excellence in contemporary aeronautics research.

Keywords: Bibliometrics, Bio-bibliometrics, Citation Analysis, Collaboration, Computational Mechanics, Dr Gangan Prathap, Non-linear Structural Mechanics, Research Productivity, Scientometrics.

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INTRODUCTION

The vast growth of global literature on all subjects, as reflected in global databases, has necessitated the need to search for methods which may provide an overview and insights into existing research within a subject field (Van, 2019; Ellegaard, 2026). The bibliometric methods, thus, emerged as a suitable method and tool for scholars to assess and map their scholarly research landscapes, evaluate scholarly output, and inform policy and strategic decision-making regarding their importance in contemporary research landscapes (Donthu *et al.*, 2021; Sohail, 2026). While bibliometric techniques were initially used mainly to assess citation counts and publication performance, their role has expanded and is used not only to analyse citation networks and research impact but also to explore collaboration patterns, emerging research topics, and thematic structures within specific domains. Bibliometric analysis is considered as a quantitative method for evaluating patterns, trends, and the impact of scholarly publications, but also provides an insightful way to assess the performance of researchers, journals, and institutions (Hoang, 2025).

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Of late, the application of bibliometric methods for evaluating and assessing the research performance of eminent scholars has emerged as an important sub-field, referred by various terminologies by scholars, such as "information profile," "bio-biblio metrics," and "scientometric portrait within bibliometrics (Sen and Gan, 1990; Kalyane and Kalyane, 1993; Gupta *et al.*, 2025). Such research aims to combine biographical data (such as career history, academic background, and institutional affiliations) with bibliometric indicators (such as publication counts, citation rates, and h-index) to trace a scholar's academic evolution and career milestones, map national and international co-authorship networks to measure a scientist's integration into the global research community, and to evaluate whether a researcher builds a distinct thematic focus (Van Den and Sandström, 2019; Patel *et al.*, 2023; Gupta *et al.*, 2025). This analysis helps scholars to make fair decisions about career advancement, funding allocation, and the overall quality of scientific research and to analyse how these factors influence the development of scientific disciplines (Roars, 2012).

Several bio-bibliometric studies in the past have focused on the analyses of contributions made by eminent Indian scientists, engineers and clinical scientists, including that of Sir C. V. Raman (Kademani *et al.*, 1994), R. Chidambaram (Kalyane and Kademani, 1995), Vikram Sarabhai (Kademani *et al.*, 2000;Kalaiappan *et al.*, 2010;Mondal *et al.*, 2018; Madhu and Kannappanava, 2020; Gupta *et al.*, 2025) among others. These studies highlight the enduring interest in evaluating scholarly impact using quantitative and qualitative bibliometric methods, besides highlighting the scholarly achievements and influence in their fields.

Despite the availability of a few bibliometric studies on individual scholars across various disciplines, a comprehensive bio-bibliometric analysis of individual researchers in the applied sciences research field remains limited and has received little attention in India, indicating a considerable gap and stressing the need for undertaking such studies. Since Dr Gangan Prathap has contributed 126 Scopus-indexed publications and made pioneering contributions to non-linear structural and computational mechanics research in India, analysing his unique scholarly output (Gupta *et al.*, 2025) becomes an appropriate case for comprehensive bio-bibliometric assessment utilising his published publications, citations received and collaborations with other scholars.

Profile Of Dr Gangan Prathap

Dr Gangan Prathap (born on 6th June 1951) is a distinguished eminent Indian aerospace engineer, structural mechanics expert, and an academician known for his groundbreaking contributions to non-linear structural mechanics and finite element analysis. His illustrious career encompasses pioneering research at major national laboratories and leadership roles across key scientific institutions, universities and academies in India.

He has obtained his B.Tech in Aerospace Engineering and Ph.D from a prestigious Indian Institute of Technology, Madras. His major research contribution was during his Ph.D from Indian Institute of Technology (IIT), Madras, Institute Fellowship for Doctoral Research at IIT Madras (Aug. 1974 - Feb. 1977), Research Assistant, Fibre Reinforced Plastics Research Centre, IIT Madras (Mar. 1977 - Aug. 1978), and Research Associate and Senior Scientist at the National Aeronautical Laboratory, Bangalore (Sep. 1978 – April 2020), and he steered production-run structural analysis for critical Indian defence and civilian aircraft projects.

Throughout his career, he served many leadership and institutional roles in high-profile organisations including the Scientist-in-Charge at the CSIR Centre for Mathematical Modeling and Computer Simulation (C-MMACS, Bangalore) (2000-2008) and later as the Director, SAARC Documentation Centre and National Institute of Science Communication and Information Resources (CSIR-NISCAIR) (Feb. 2009-June 2013) and Outstanding Scientist, NISCAIR, New Delhi (July - Aug. 2013) and Director NIIST, Thiruvananthapuram (Aug. 2013-Jun. 2015); Honorary Professor, APJ Abdul Kalam Technological University, Thiruvananthapuram (2015-2024) and Academic and Research Director, Vidya International Charitable Trust, Thrissur (2015-2018) and Scholar at Large, Kerala State Higher Education Council (2024-2026)

The prestigious awards and honors received by him include (i) Shanti Swarup Bhatnagar Prize (1990), a highest multidisciplinary science prize in the Engineering Sciences category for his outstanding contributions to computational mechanics; (ii) Elected as a Fellow of both the Indian Academy of Sciences (1990) and the Indian National Science Academy for his foundational engineering algorithms; (iii) DAAD Academic Exchange Fellowship, a prestigious fellowship from Germany (1983-1984); (iv) Honorary Senior Fellow from Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore; and High Impact Research Icon of University of Malaya (Jul. 2015-Jun. 2016) and Visiting Professor, Institute of Computer Science and Digital Innovation, UCSI University, Malaysia (Sep. 2020-Aug 2022 and Mar. 2023-Feb. 2025). He was also a Fellow of the World Innovation Foundation, Life Member of the Indian Society for Theoretical and Applied Mechanics, Indian Society for Advancement of Materials and Process Engineering, Indian Society for Mathematical Modeling and Computer Simulation and Current Science Association.

He was associated with various professional journals: Associate Editor, Journal of the Aeronautical Society of India (1980-1982), Editor, Sadhana, Journal of Engineering Sciences (1999-2006) and Editor-in-Chief, Computers, Materials and Continua (2005-2006). He was a member of the editorial board of Resonance

(1996-2002), International Journal for Engineering Analysis and Design, Computer Modelling and Simulation in Engineering, International Journal of Computational Engineering Science, and DESIDOC Journal of Library and Information Technology. From 1977 till now, he has reviewed papers for more than 30 journals. He was the Guest Editor (Jointly with T. K. Varadan) of the Special Issue of Sadhana on Non-linear Structural Analysis (2000, Vol. 25 (No. 4)).

He has authored over 400 scientific papers, reports, books (including The Finite Element Method in Structural Mechanics), and numerous papers in high-impact international journals. Till today, his 332 publications are indexed in Scopus from 1975 to 2024. Stanford University researchers recognised Dr Prathap as being among the top 2% of scientists in the world based on standardised lifelong citation metrics.

Research Contribution Of Dr Gangan Prathap In Non-Linear Structural And Computational Mechanics

Early stage

His early work was on the Finite Element Method (FEM). This is a computational methodology used to design and test complex structures like aircraft, ships, buildings, bridges, etc. It breaks down the structure into elements, nowadays as many as a million pieces, and models how, under loads, it bends and stretches, going up to failure. In the early stages of the development of the methodology, an error called "shear locking" resulted in very inaccurate results, as if the structure was far stiffer than it actually was noticed.

Dr Prathap and his team invented the concept of "field-consistent" elements to address this issue. This improved matters and led to accurate and reliable simulations. Three key lines of research and scholarship followed:

(i) Robust Element Design: The design and implementation of consistent, variationally correct, and error-free finite elements used in structural mechanics;

(ii) Field-Consistent Interpolations: Pioneering techniques like field-consistent strain interpolations to prevent numerical locking and instability in elements (such as shear-flexible beams and plates); and (iii) Authoritative Book: A monograph entitled "The Finite Element Method in Structural Mechanics", addressing the scientific and mathematical foundations behind reliable element design.

Earlier, FEM was rationalised through the principle of minimum total potential energy, which argues that from computed displacement, strains and stresses are approximated (Hetnarski, 2014). Instead, from the generalised Hu-Washizu principle, the Stress Correspondence Paradigm argued that FEM samples strains and stresses first, and generates displacement fields from these. This approach provided engineers with prior error estimates of errors and the exact quality and accuracy of a finite element solution before running simulations. With his students, this was later adapted to systematically address accuracy in complex elastodynamic (vibration and impact) structural problems.

The canonical rules of finite element modelling were extended beyond the classical rules of continuity and completeness, as the C-concepts, which include: (i) Field Consistency: Ensuring strain fields match accurately; (ii) Variational Correctness: Ensuring that the energy approximations within the element accurately mirror the true physics of the problem.

FEM Applications to various Aircraft and other Structural Applications

From 1986 to 1992, his group at the National Aerospace Laboratories (NAL) in Bangalore translated the theoretical research into practical engineering applications. The FEPACS (Finite Element Package for Analysis of Composite Structures) was developed for in-house use (Naganarayana *et al.*, 1996). From 1992 to 2000, FEPACS, along with industry-standard commercial packages like NASTRAN, ANSYS, and ABAQUS, was used for routine production-run structural design and analysis. Typical applications included advanced aircraft projects such as the Light Combat Aircraft, the SARAS Light Transport Aircraft and the Composite Rudder and Fin Projects at the National Aerospace Laboratories in Bengaluru.

Non-linear Structural Mechanics

From 1975 to 1978, beginning at IIT Madras and continuing at NAL, studies of various non-linear structural mechanics issues related to commonly used plate and shell structures were made. This led to research papers resolving long-standing debates regarding the non-linear vibrations and behaviour of thin plates and shells, and the complex behaviour of structural bodies under severe buckling and post-buckling conditions.

In sum, the authors have tried to offer a coherent narrative of Dr Prathap's work in computational mechanics. There are three distinct phases: (i) Early stage, 1975-1982. The solution to various non-linear structural problems using computational models to solve differential and integro-differential problems; (ii) The FEM stage, 1978-1992. Work on conceptual paradigms like the Field-consistency principle, and development of elements based on these principles; and (iii) FEM applications, especially to production-run stress analysis. From 1992 to 2000, use of the in-house software package FEPACS and other industry-standard packages for aircraft stress analysis.

A bibliometric analysis of his 126 papers can broadly divide the above contributions of Dr Prathap into the following four areas: (i) The Finite Element Method (FEM). Theory, like the Field-Consistency Paradigm and the Stress Correspondence Principle (36 papers, 578 citations, 16.06 CPP), and the Finite Element Method (FEM). New Elements, especially the Field-consistent and Higher-order Theory Elements (37 papers,

918 citations, 24.81 CPP), (iv) and the Finite Element Method (FEM). Applications to various Aircraft and other Structural Applications; and (v) one paper in Acoustic Emission applications (Hetnarski, 2014).

METHODOLOGY

The present study analyses and assesses the research contribution of Dr Gangan Prathap using standard bibliometric methods. Relevant publication data for this study was sourced from a widely recognised international bibliographic and citation database, called as the Scopus database. Using the "Author ID" 58179 tag, the authors developed a search strategy and executed it on October 28, 2026, using the author's name and institutional affiliation, retrieving a total of 332 research documents. Later, the authors identified and selected 126 out of 332 papers by Dr Prathap, explicitly related to non-linear structural and computational mechanics, with the help of Dr Prathap, two experts in the field and later by the authors to check their authenticity. The inclusion criteria indicate that the 126 documents include only research articles, reviews, editorials, letters and notes, and the period selected pertained to 1975-2010. A descriptive and evaluative bio-bibliometric methodology was adopted. Select bibliometric indicators were employed for assessing the research performance of Dr Prathap, including its Total Publications in peer-reviewed journals (TP), total citations received from TP (TC), Citations registered Per Paper (CPP) and the Relative Citation Index (RCI), which measures the scientific influence of an author/institution relative to a country or scientific field. Dr Prathap collaboration network with authors, institutions, countries and keywords was visualised using VOSviewer software, generating co-authorship and keyword co-occurrence networks.

RESULTS AND DISCUSSION

Overall Picture

Dr Prathap published 126 papers in non-linear structural and computational mechanics during 1975-2010 (33 years), depicting 3.82 publications per year. The annual publications of Dr Prathap showed a fluctuating growth and decline trend during this period, with the maximum number of publications (15, 9, and 8) reported during 1976, 1986 and 1996. There were no publications during 1998 and 2000. The 11-year cumulative publications, however, showed a decreasing trend from 50 during 1976-85 to 48 during 1986-96 and finally to 29 publications during 1997-2010. Dr Prathap's 126 papers received 2514 citations in total, averaging 19.95 citations per paper. However, the average citations per paper decreased from 21.76 CPP during 1975-85 to 19.63 CPP during 1986-96 and to 16.69 CPP during 1997-2010 (Table 1 and Figure 1).

Dr Prathap's total research output comprises of 108 original articles (85.71% share), letters (11 and 8.73% share), notes (4 and 3.17% share), conference papers (2 and 1.59% share) and reviews (1 paper and 0.79% share), Among these document types, the highest citation impact per paper (22.51), was registered by articles, followed by letters (8.73 CPP), notes (2.25 CPP), reviews (2.0 CPP) and conference papers (0.50 CPP) (Bala and Gupta, 2009).

Funding was limited and temporally concentrated. Only 5 of the 126 publications were identified as funded. No funded publications were recorded thereafter. These five funded papers collectively received 267 citations, representing approximately 10.56% of total citations despite accounting for only 3.97% of publications. The concentration of funded research in the earlier career period suggests that formal grant support was selective and time-bounded, while the majority of Dr Prathap's publication output was produced without funding.

Collaboration Rate, Collaboration Coefficient and Authorship Status

During a particular period, the ratio of multi-authored papers to the total number of papers published is defined as the Collaboration Rate (CR) by scholars. For 126 publications of Dr Prathap's, the value of CR was found to be 0.78 during 1975-2010, which, however, increased from 0.76 during 1975-91 to 0.80 during 1992-2010. This indicates that his majority share of papers were multi-authored, and only 28 (22.2%) were single-authored. The value of CC for Dr Gangan Prathap's 126 publications, as calculated from the formula suggested by Ajiferuke *et al.* (1988), was found to be 0.61 during 1975-2010. Observing the values of CR and CC observed, it can be concluded that Dr Prathap published a large number of collaborative research papers (in collaboration with many scholars), indicating his primary choice to work in a team rather than working alone as an individual (Garg and Kumar, 2019).

Dr Prathap, in his 126 publications, occupied primary authorship (or first author) in 78 (75.28%) papers and acted as a co-author in the remaining 48 (24.72%) papers. Among his co-authored papers, he held the 2nd position in 29(7.86%) papers, the 3rd position in 18 (6.74%) papers, and the 4th position in 1 (4.49%) paper. The above analysis indicates that Dr Prathap occupied a prominent authorship position (either first or second) in more than 80% of his total papers (Garg and Kumar, 2019).

Intra-departmental and Inter-institutional collaboration

The 85 (67.42%) out of 126 publications by Dr Prathap involve participants from only one organisation and are considered as intra-departmental collaboration. In contrast, under inter-institutional collaboration involving participation of 2 or more organisations, only 35 and 6 are national and international collaborations.

Among these 85 (67.42%) intra-departmental collaboration papers, 28 papers had independent authorship, while the 57

Table 1: Annual growth of papers and citations of Dr Gangan Prathap during 1975-2010.

Year	TP	TC	CPP	Year	TP	TC	CPP	Year	TP	TC	CPP
1975	1	0	0.00	1986	9	346	38.44	1997	2	22	11.00
1976	2	80	40.00	1987	5	118	23.60	1999	3	6	2.00
1977	4	41	10.25	1988	2	64	32.00	2001	1	40	40.00
1978	15	180	12.00	1989	5	107	21.40	2002	4	142	35.50
1979	2	29	14.50	1990	4	61	15.25	2003	2	19	9.50
1980	5	156	31.20	1991	1	6	6.00	2004	5	140	28.00
1981	3	88	29.33	1992	4	42	10.50	2005	3	51	17.00
1982	2	225	112.50	1993	4	18	4.50	2006	2	16	8.00
1983	3	74	24.67	1994	4	58	14.50	2007	3	16	5.33
1984	6	15	2.50	1995	2	28	14.00	2008	3	14	4.67
1985	7	200	28.57	1996	8	94	11.75	2010	1	18	18.00
1975-85	50	1088	21.76	1986-96	48	942	19.63	1997-10	29	484	16.69
Total								1975-2010	126	2514	19.95

Missing years=1998, 2000.

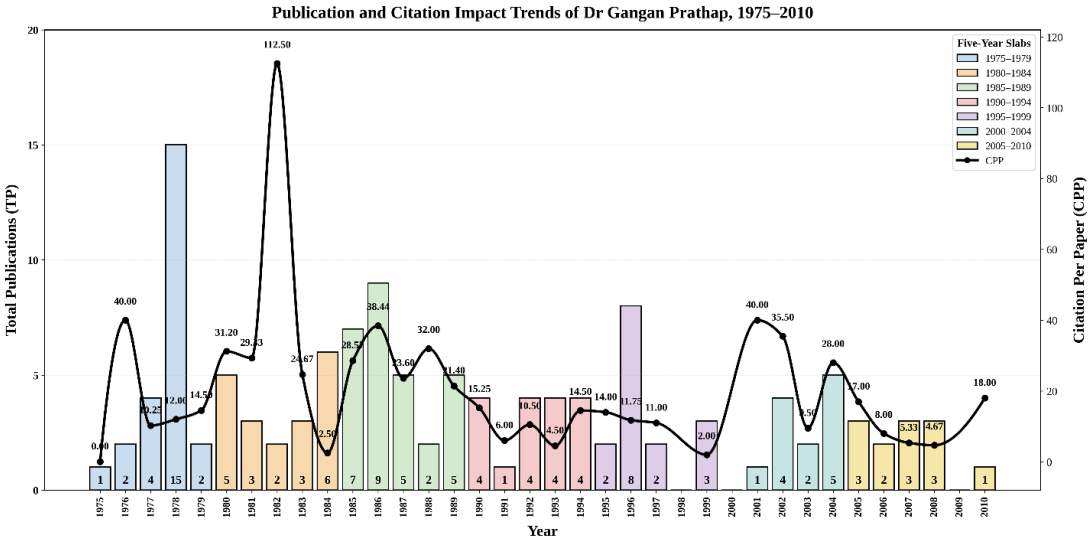

Figure 1: Research productivity and citation impact of Dr Gangan Prathap, 1975-2010.

remaining indicate involvement of two or more authors. The 85 intra-departmental collaborative papers by Dr Prathap collectively registered 1836 citations, averaging 21.6 citations per paper. Dr Prathap's 6 (25.84%) international collaborative publications (ICPs) collectively registered 10 citations (average=1.67 CPP). Among 126 publications by Dr Prathap, a substantial number, 35 (76.40%), indicate national collaboration with 10 national organisations. The 35 national collaborative papers collectively registered 553 citations (averaging 15.8 CPP).

Most Productive Affiliations and Collaboration

Dr Prathap's research output is primarily affiliated with the National Aerospace Laboratory, Bangalore, contributing 72 papers, a significant share of his 126 total publications. Other key affiliations include the C-MMCS, Bangalore (252 papers), Indian Institute of Technology, Madras (23), Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore (5 papers), Institute fur Struckturmechanik, DEVLR, Germany (4 papers), NISCAIR, New Delhi (1 paper) (Singh and Gupta, 2010). In 35 (76.40%) national collaboration papers, Dr Prathap collaborated with 10 leading national organisations and the collaborative papers resulted in following collaborative pairs: C-MMCS, Bangalore and NAL, Bangalore (17 papers), followed by NAL, Bangalore and IIT, Madras (10 papers), C-MMCS, Bangalore and IIT-Kharagpur (8 papers), NAL, Bangalore and Defence Research and Development Lab., Hyderabad (3 papers), C-MMCS, Bangalore and CSS Foundation, Bangalore, NAL, Bangalore and Hindustan Aeronautics Ltd, Bangalore and NAL, Bangalore and Aeronautical Development Agency, Bangalore (2 papers each), NAL, Bangalore and IISc, Bangalore, JNCASR, Bangalore and

Hindustan Aeronautics Ltd, Bangalore, and JNCASR, Bangalore and NAL, Bangalore (1 paper each) (Table 2).

Most Productive Authors and Collaboration

Table 3 presents the prolific collaborators of Dr Prathap in producing 85 intra-departmental collaborative papers, 35 inter-departmental national collaborative papers, and 6 inter-departmental international collaborative papers. These involved a cumulative total of 138 authorships and 43 unique individual co-authors. His eight most frequent collaborators include Varadan TK (23 papers), Naganarayana BP (10 papers), Babu CR and Raja S (8 papers each), Sinha PK (7 papers), Bhashyam GR (5 papers), Jafarali P, Vinayak RU, Senthilkumar V, and Somashekar BR (4 papers each), who are considered her closest collaborators based on collaborative publication count. These 11 collaborators together account for 94 co-authored papers, demonstrating that Dr Prathap's collaborative output was substantially anchored in a recurring core of research partners. The next group of 9 co-authors have contributed 2-3 papers each, while the remaining 23 collaborators have co-authored one paper each. The majority of her close collaborators are affiliated with her home institutions through intra-departmental collaboration, and others co-authored through inter-institutional collaboration.

Citation impact varies considerably with collaboration frequency. Bhashyam G. R., despite only 5 publications, records the highest citation performance among the major collaborators (91.0 CPP). Other comparatively high-impact collaborators include Somashekar B. R. (39.5 CPP), Sinha P. K. 35.0 CPP), Dwarakanathan D. (35.0 CPP), and Raja S. (34.75 CPP).

Figure 2 presents the VOSviewer co-authorship network of 43 authors across 17 clusters, 74 links, and a Total Link Strength (TLS) of 188, using a minimum threshold of one publication. The network is strongly centralised around Dr Prathap G, who records 43 links and TLS 139, substantially exceeding the corresponding values of other authors. This position identifies Dr Prathap as the principal connecting node across the collaborative network. The strongest secondary connections are associated with Varadan T. K. (7 links; 30 TLS), Naganarayana B. P. (7; 25 TLS), Raja S. (5; 20 TLS), Sinha P. K. (4; 18 TLS), Mukherjee S. (4; 14 TLS), and Babu C. R. (3; 13 TLS). These relationships correspond closely with the most frequent collaborators identified in Table 3 and form the principal collaborative backbone around Dr Prathap.

Table 2: Major Indian organisations collaborating with Dr. Gangan Prathap.

Sl. No.	Name of the collaborating organisation	TP	TC	CPP	%TP
1.	C-MMCS, Bangalore – National Aeronautical Laboratory, Bangalore	17	231	13.59	13.49
2.	National Aeronautical Laboratory, Bangalore – Indian Institute of Technology, Madras	10	79	7.9	7.94
3.	C-MMCS, Bangalore – Indian Institute of Technology (IIT), Kharagpur	8	277	34.62	6.35
4.	National Aeronautical Laboratory, Bangalore – Defence Research and Development Laboratory, Hyderabad	3	61	20.33	2.38
5.	C-MMCS, Bangalore – CSS Foundation, Bangalore	2	43	21.5	1.59
6.	National Aeronautical Laboratory, Bangalore – Hindustan Aeronautics Ltd., Bangalore	2	17	8.5	1.59
7.	National Aeronautical Laboratory, Bangalore – Aeronautical Development Agency, Bangalore	2	0	0	1.59
8.	Institute fur Strukturmechanik, DFVLR, Brawischweig, Germany – Indian Institute of Technology, Madras	2	7	3.5	1.59
9.	National Aeronautical Laboratory, Bangalore –Indian Institute of Science, Bangalore	1	16	16	0.79
10.	Jawaharlal Nehru Centre for Advanced Research, Bangalore – Hindustan Aeronautics Ltd., Bangalore	1	27	27	0.79
11.	Jawaharlal Nehru Centre for Advanced Research, Bangalore – National Aeronautical Laboratory, Bangalore	1	13	13	0.79
12.	Institute fur Strukturmechanik, DFVLR, Brawischweig, Germany – Defence Research and Development Laboratory, Hyderabad	1	1	1	0.79
13.	Institute fur Strukturmechanik, DFVLR, Brawischweig, Germany – National Institute of Technical Training and Industrial Engineering, Mumbai	1	6	6	0.79
14.	C-MMCS, Bangalore – National Aeronautical Laboratory, Bangalore	17	231	13.59	13.49

TP=Total Publications; TC=Total Citations; CPP=Citations per Paper.

Table 3: Profile of the 43 Indian authors co-working with Dr Gangan Prathap through collaboration.

Sl. No.	Name	Affiliation	TP	TC	CPP	TLS	S. No	Name	Affiliation	TP	TC	CPP	TLS
1.	Varadan TK	IIT, Madras	23	307	13.35	30	23	Holla VK	HAL, Bangalore	1	0	1.00	2
2.	Naganarayana BP	NAL, Bangalore	17	313	18.41	25	24	Parameswaran K	IIT, Madras	1	1	1.00	2
3.	Babu CR	NAL, Bangalore	10	382	38.20	13	25	Dilip VR	IIT, Madras	1	1	0.00	2
4.	Mukherjee S	NAL, Bangalore	8	80	10.00	14	26	Ameen M	NITC, Calicut	1	0	8.00	3
5.	Raja S	NAL, Bangalore	8	278	34.75	20	27	Chattopadhyay L	NAL, Bangalore	1	8	2.00	3
6.	Sinha PK	IIT, Kharagpur	7	245	35.00	18	28	Mohan PR	HAL, Bangalore	1	2	27.00	2
7.	Bhashyam GR	University of Arizona, USA	5	455	91.00	5	29	Dattaguru B	IISc, Bangalore	1	27	16.00	3
8.	Jafarali P	C-MMACS, Bangalore	4	19	4.75	10	30	Ramamurty TS	IISc, Bangalore	1	16	16.00	3
9.	Vinayak RU	NAL, Bangalore	4	76	19.00	6	31	Sreedeep R	NAL, Bangalore	1	16	33.00	2
10.	Senthilkumar V	C-MMACS, Bangalore	4	52	13.00	7	32	Bhattacharya P	NAL, Bangalore	1	33	22.00	3
11.	Somashekar BR	NAL, Bangalore	4	158	39.50	7	33	Chandra S	NAL, Bangalore	1	22	29.00	1
12.	Dwarakanathan D	NAL, Bangalore	3	105	35.00	9	34	Pradhan SC	IIT, Kharagpur	1	29	18.00	2
13.	Pandalai KAV	IIT, Madras	3	30	10.00	3	35	Eggers H	Institute of Structural Mechanics, Germany	1	18	0.00	2
14.	Viswanath S	NAL, Bangalore	3	59	19.67	3	36	Pillai SR	Institute of Structural Mechanics, Germany	1	0	0.00	2
15.	Sarma BS	DRDL, Hyderabad	2	28	14.00	4	37	Balasubramanian TS	NAL, Bangalore	1	0	29.00	1
16.	Rajendran S	NAL, Bangalore	2	5	2.50	4	38	Kumar S	C-MMACS, Bangalore	1	29	4.00	1
17.	Sangeeta K	C-MMACS, Bangalore	2	2	1.00	4	38	Dilip VR	IIT, Madras	1	4	0.00	2
18.	Mohan R	NAL, Bangalore	2	22	11.00	4	40	Kumar S	C-MMACS, Bangalore	1	0	4.00	1
19.	Manju S	NAL, Bangalore	2	20	10.00	4	41	Murthy MVV	NAL, Bangalore	1	4	2.00	1
20.	Subramanian G	IIT, Madras	2	16	8.00	4	42	Nirmala K	NAL, Bangalore	1	2	4.00	1
21.	Ramani HV	DRDL, Hyderabad	1	33	33.00	2	43	Shashirekha BR	NAL, Bangalore	1	4	12.00	1
22.	Kumar BSS	NITIE, Bombay	1	6	6.00	2	TLS=Total Link Strength						

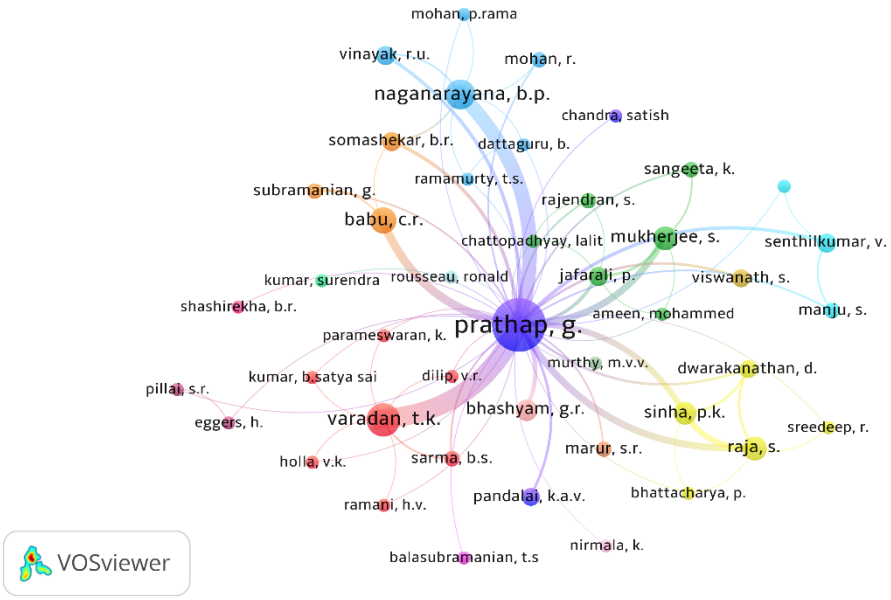

Figure 2: Author Co-authorship Network of Gangan Prathap's Research Publications.

The 17 clusters reveal distinct institutional and collaborative communities. Cluster 1 centres on Varadan T. K. and connects researchers associated with IIT Madras, DRDL, Hyderabad, NITIE Bombay, and HAL, Bangalore. Cluster 2 is concentrated around NAL Bangalore and C-MMACS Bangalore, whereas Cluster 3 connects NAL Bangalore and IISc Bangalore through Naganarayana B. P. and associated collaborators. Cluster 4 links researchers from NAL Bangalore and IIT Kharagpur, particularly around Raja S. and Sinha P. K. Cluster 5, the largest Dr Prathap-centred community, connects researchers from NAL, IIT Madras, C-MMACS, and IIT Kharagpur. The remaining clusters are smaller and represent more limited collaborative relationships.

International collaborators occupy relatively peripheral positions in the network. Eggers H. and Pillai S. R. form Cluster 8 and are affiliated with the Institute of Structural Mechanics, Germany; Bhashyam G. R. constitutes Cluster 10 and is affiliated, of late, with the University of Arizona, USA; Cluster 5. Their peripheral positioning reinforces the numerical evidence of relatively limited international integration and a predominantly domestic collaborative structure.

Media of Communication and Core Sources

Of the 126 publications by Dr Prathap, 124 were published in 28 journals and 2 in conference proceedings. The 28 journals have Impact Factors (IFs) ranging from 0.9 to 24.2, with six journals reporting an IF above 5.6. The most productive journal was *International Journal of Numerical Methods in Engineering* (26 papers), followed by *Computers & Structures* (25 papers), *Journal of Sound and Vibration* (20 papers), *Sadhana* (8 papers), *AIAA Journal* (7 papers) and *Structure Engineering and Mechanics* (6 papers). These six journals reflect the central importance of Dr Prathap's contribution and together contributed 92 papers, accounting for a 74.19% share of his total contribution.

Among these 28 journals, Smart Materials and Structures registered the highest citation per paper (84.0), followed by Computational Mechanics (41.0 CPP), International Journal of Numerical Methods in Engineering (34.19 CPP), Journal of Intelligent Materials and Systems Structures (33.0 CPP), Composite Structures and Progress in Aerospace Sciences (27.0 CPP each) and Journal of Sound and Vibration (23.45 CPP). Similarly, Progress in Aerospace Sciences reported the highest (IF=24.2) (n=1), followed by Composite Structures (IF=7.8) (n=1), Computer Methods in Applied Mathematics and Engineering (IF=7.6) (n=5), Aerospace Science and Technology (IF=6.4) (n=1), and Journal of Sound and Vibration (IF=5.8) (n=20).

Table 4 shows that among Dr Prathap's publications, 92.75% (115) appeared in international journals, with the UK leading (13 journals, 52.42%), followed by the Netherlands (4 journals, 22.58%), the USA (6 journals, 11.29%), and others. The remaining 7.26% were in 2 domestic journals. Of the 28 participating journals, 3 were Asian, 19 European, and 6 North American. The UK is the preferred destination, considered the common practice among Indian researchers.

The 8.94% of Dr Prathap's publications were published in 3 low IF (<1) journals, 44.72% in 15 medium IF (2.3-3.8) journals, and 46.34% were in 9 high IF (4.5-24.2) journals. One journal did not report impact factor information. By quartiles, 99.18% (25 journals, 121 papers) appeared in Q1/Q2 journals and 0.82%

Table 4: Profile of the 28 journals contributing to Gangan Prathap's publications.

Sl. No.	Name of the journal	TP	TC	CPP	IF	Q	Publisher	Place of publication
1.	International Journal of Computational Methods in Engineering	26	889	34.19	3.3	Q1	John Wiley and Sons, UK	UK
2	Computers and Structures	25	467	18.68	5.6	Q1	Elsevier, UK	UK
3	Journal of Sound and Vibration	20	469	23.45	5.8	Q1	Elsevier, Netherlands	Netherlands
4	Sadhana	8	53	6.63	1.6	Q2	Indian Academy of Sciences, Bangalore	India
5	AIAA Journal	7	84	12.00	3.2	Q1	American Institute of Aeronautics and Astronautics	USA
6	Structure Engineering and Mechanics	6	19	3.17	3.2	Q2	Techno-Press	South Korea
7	Computer Methods in Applied Mathematics and Engineering	5	49	9.80	7.6	Q1	Elsevier B.V., Netherlands	Netherlands
8	Journal of Applied Mechanics Transactions ASME	4	66	16.50	2.7	Q2	Amer Soc for Mechanical Engineers	USA
9	Journal of Reinforced Plastics and Composites	2	20	10.00	2.3	Q2	Sage Publications	UK
10	Smart Materials and Structures	2	168	84.00	3.8	Q2	IOP Publishing Ltd	UK
11	Finite Elements in Analysis and Design	2	10	5.00	3,8	Q1	Elsevier	Netherland
12	Advanced Composite Materials	1	15	15.00	2.7	Q2	Taylor and Francis	UK
13	Advanced Science Letters	1	18	18.00	1.253	NA	American Scientific Publishing	USA
14	Aerospace Science and Technology	1	22	22.00	6.4	Q1	Elsevier	France
15	Composite Structures	1	27	27.00	7.8	Q1	Elsevier B.V.	Netherlands
16	Computational Mechanics	1	41	41.00	4.5	Q1	Springer-Verlag	Germany
17	Current Science	1	12	12.00	0.9	Q3	Indian Academy of Sciences, Bangalore	India
18	International Journal of Computational Methods in Engineering Sciences and Mechanics	1	1	1.00	1.2	Q2	Taylor and Francis	UK
19	International Journal of Computational Engineering Science	1	2	2.00	NA	NA	World Scientific Publishing (Not Active)	UK
20	International Journal of Non-Linear Mechanics	1	5	5.00	3.4	Q1	Elsevier Ltd	UK
21	International Journal of Solids and Structures	1	2	2.00	4.6	Q1	Elsevier Ltd, NY	USA

Sl. No.	Name of the journal	TP	TC	CPP	IF	Q	Publisher	Place of publication
22	Journal of Acoustic Society of America	1	1	1.00	2,6	Q1	Acoustic Society of America	USA
23	Journal of Intelligent Materials and Systems Structures	1	33	33.00	2.7	Q2	Sage	UK
24	Journal of Non-Destructive Evaluations	1	6	6.00	3	Q2	Springer	USA
25	Journal of Non-Linear Mechanics	1	5	5.00	3.4	Q1	Elsevier Ltd	UK
26	Journal of Solids and Structures	1	2	2.00	4.6	Q1	Elsevier Ltd	UK
27	Mechanics Research Communication	1	0	0.00	2.3	Q2	Elsevier Ltd	UK
28	Progress in Aerospace Sciences	1	27	27.00	24.2	Q1	Elsevier Ltd	UK
Total		124	2514	20.27	IF=Impact Factor; Q=Quartile			

(1 journal, 1 paper) in Q3 journals, reflecting strong publication quality. Two journals did not report quartile data.

Keyword Co-occurrence Network

Keyword selection began with 422 keywords from Gangan Prathap's 126 Scopus-indexed publications. After thesaurus-based consolidation of spelling, hyphenation, plural, and Compendex-subdivision variants, 357 unique terms remained. Two parsing artefacts were excluded. Keywords were ranked by occurrence, with TLS used as a tiebreaker, and then reviewed for thematic relevance. Generic terms such as mathematical techniques and problem solving were removed, while substantively important terms such as membrane locking and piezoelectric materials were retained. The final set of 50 keywords therefore reflects both frequency and thematic significance.

Figure 3 shows a network of 50 keywords, 471 links, and TLS=873, organised into four thematic clusters. *Cluster 1 (red)*: Finite Element Methods and Numerical Analysis contain 16 keywords. It is dominated by finite element method (OCC=55; Links=49; TLS=208), followed by mathematical models (10; 29; 62), stress analysis (8; 26; 47), error analysis (7; 24; 45), and approximation theory (7; 19; 41). Other terms include convergence of numerical methods, best-fit paradigm, variational techniques, locking, mesh distortion, computational methods, and finite element discretisation. This cluster represents the methodological core, with strong emphasis on numerical accuracy and finite element formulation.

Cluster 2 (green): Vibration and Active Structural Control contains 13 keywords, led by vibrations (8; 23; 31), actuators (7; 21; 48), stiffness (5; 24; 31), composite beams and girders (4; 24; 34), sensors (4; 17; 29), vibration control (4; 16; 30), and piezoelectricity (4; 15; 25). Active stiffening, piezoelectric devices, feedback control, damping, deformation, and boundary conditions complete the cluster. The pattern indicates a focused stream on vibration control and smart structural systems, linking piezoelectric materials, sensing, actuation, and feedback.

Cluster 3 (purple): Plates, Composites and Structural Mechanics contains 12 keywords. Plates (27; 40; 100) and structural analysis (25; 30; 67) are the strongest terms, followed by laminated composites (6; 29; 44), elasticity (6; 24; 35), and shear deformation (6; 19; 33). Thermal stress, Lagrange multipliers, composite structures, bending, higher-order theory, shear stress, and piezoelectric materials are also included. The cluster reflects research on structural components, composite materials, and refined structural formulations.

Cluster 4 (yellow): Beams, Strain and Field Consistency contains nine keywords, centred on beams and girders (37; 29; 87), strain (20; 34; 92), stresses (16; 24; 56), field consistency (11; 13; 36), and domes and shells (11; 9; 19). Shear locking, curved beam element, stress oscillations, and membrane locking are also present. The cluster highlights beam and shell formulations, stress–strain behaviour, and numerical consistency, particularly the treatment of locking and related finite element deficiencies.

Central and bridging keywords. The finite element method is the dominant network hub, with the highest occurrence, links, and TLS. Plates, strain, beams and girders, structural analysis, and mathematical models are also prominent and connect methodological and structural themes. Stress analysis, elasticity, laminated composites, stiffness, and composite beams and girders provide links across structural and materials-related topics, while actuators, piezoelectricity, and vibration control connect

smart-structure research with the wider structural-mechanics domain.

Highly cited publications

Citation distribution pattern

Dr Prathap's 126 publications collectively received a total of 2514 citations (average: 19.95 CPP). The citation distribution analysis revealed the following: (i) Only a small percentage of 5.50% (7 papers) of the total publications received zero citations. (ii) Conversely, the majority (94.50%) of the total papers were cited at least once. Specifically, 59 papers (46.82%) have a citation range of 1-10, accounting for 9.98% of the total citation share. Additionally, 35 papers (27.78%) were cited in the range 11-30, representing 26.97% (678) of the citation share. The remaining papers received citations as follows: 13 papers (10.32%) received 492 citations (19.57% citation share), 8 papers (6.35%) received 544 citations (22.64% citation share), and 4 papers (3.17%) received 559 citations (22.24% citation share) (Gupta *et al.*, 2025).

Characteristics of HCPs

The top 20 (15.87%) of Dr Prathap's 126 publications are assumed to be Highly Cited Papers (HCPs), as they received between 45 and 120 citations. Collectively, these 20 HCPs garnered a total of 1431 citations (56.92% share of the total citations), averaging 371.55 CPP. Table 5 lists the top 10 HCPs (Gupta *et al.*, 2025).

The citation distribution among these HCPs is quite uneven: three papers were in the 110-220 citation range, as against 9 papers and 8 papers having 56-97 and 37-45 citation ranges, respectively. These HCPs were published in three journals, with four papers involving collaboration.

The 20 HCPs were published from 1976 to 2005, with 4 papers in 1986, 2 papers each in 1985 and 1988 and 1 paper each in other years. Of the top 20 HCPs, only 14 involve intra-departmental collaboration and 6 involve inter-institutional collaboration: 5 national collaborative and 1 international collaborative. During intra-departmental collaboration, he collaborated with 6 colleagues, namely C.R. Babu (4 papers), G.R. Bhashyam and B.R. Somashekar (3 papers each), B. Naganarayana (2 papers) and S. Mukherjee and S. Viswanath (1 paper each). During international collaboration, he collaborated with T.K. Varadhan and S.Raja (2 papers each), P.K.Sinha, S.R. Marur, D.Dwarakanathan and R.U.Vinayak (1 paper each).

The 20 HCPs appeared in 6 international journals, with 9 papers in International Journal of Numerical Methods in Engineering (IF=2.7), 5 papers in Computers and Structures (IF=5.6), 2 papers in Journal of Sound and Vibration (IF=5.8) and 1 paper each in Computational Mechanics (IF=4.5), Journal of Applied Mechanics Transactions ASME (IF=2.7) and Smart Materials and Structures (IF=3.8).

Among the top 20 HCPs. Dr Prathap had published 16 HCPs while working at National Aeronautical Laboratory, Bangalore, 3 HCPs while working at C-MMACS, Bangalore and 1 HCP while working at IIT, Madras.

The most cited paper among Dr Prathap's publications was titled "Reduced integration and the shear-flexible beam element" (202 citations) by Prathap, G. and Bhashyam, G.R. and published in the International Journal of Numerical Methods in Engineering in 1982 (Prathap and Bhashyam, 1982). In this paper, the authors explain the mathematical origins of shear locking in finite elements and demonstrate how reduced numerical integration

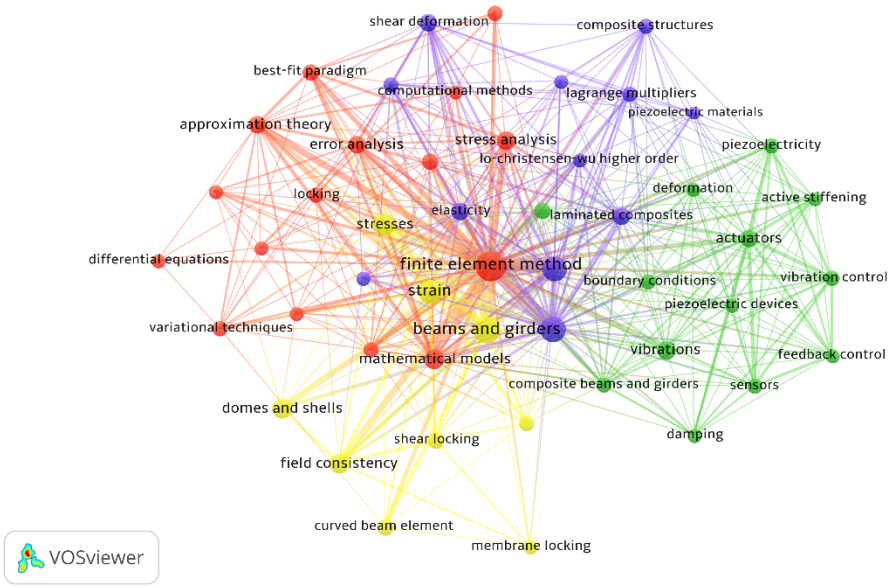

Figure 3: Keyword Co-occurrence Map of top 50 Keywords.

Table 5: List of the top10 highly cited publications authored by Dr Prathap.

Title	Name of authors	Affiliation of authors	Source	TC
Reduced integration and the shear-flexible beam element (Article)	Prathap G., Bhashyam G.R.	Structures Division, National Aeronautical Laboratory, Bangalore, India	International Journal for Numerical Methods in Engineering, 1982, 18(2)	220
Galerkin finite element method for non-linear beam vibrations (Article)	Bhashyam G.R., Prathap G.	Structures Division, National Aeronautical Laboratory, Bangalore, 560 017, India	Journal of Sound and Vibration, 1980, 72(2)	132
Active vibration control of composite sandwich beams with piezoelectric extension-bending and shear actuators (Article)	Raja S., Prathap G., Sinha P.K.	Department of Aerospace Engineering, Indian Institute of Technology, Kharagpur; Center for Mathematical Modeling and Computer Simulation, Bangalore	Smart Materials and Structures, 2002, 11(1)	110
The curved beam/deep arch/finite ring element revisited (Article)	Prathap G.	Structural Sciences Division, National Aeronautical Laboratory, Bangalore, India	International Journal for Numerical Methods in Engineering, 1985, 21(3)	97
A linear thick curved beam element (Article)	Babu C.R., Prathap G.	Structural Sciences Division, National Aeronautical Laboratory, Bangalore, 560017, India	International Journal for Numerical Methods in Engineering, 1986, 23(7)	87
The second frequency spectrum of Timoshenko beams (Article)	Bhashyam G.R., Prathap G.	Department of Aerospace and Mechanical Engineering, University of Arizona, Tucson, AZ 85721, United States; Structures Division, National Aeronautical Laboratory, Bangalore, 560 017, India	Journal of Sound and Vibration, 1981, 76(3)	87
An isoparametric quadratic thick curved beam element (Article)	Prathap G., Babu C.R.	Structural Sciences Division, National Aeronautical Laboratory, Bangalore, 560017, India	International Journal for Numerical Methods in Engineering, 1986, 23(9)	72
A field-consistent, four-noded, laminated, anisotropic plate/shell element (Article)	Somashekar B.R., Prathap G., Babu C.R.	National Aeronautical Laboratory, Structural Sciences Division, Bangalore, 560017, India	Computers and Structures, 1987, 25(3)	65
The inelastic large deformation of beams (Article)	Prathap G., Varadan T.K	Department of Aeronautical Engineering, IIT, Madras, India	Journal of Applied Mechanics Transactions ASME, 1976, 43(4)	62
Thermally induced vibration control of composite plates and shells with piezoelectric active damping (Article)	Raja S., Sinha P.K., Prathap G., Dwarakanathan D.	Structures Division, National Aerospace Laboratories, Bangalore-560017, India; Department of Aerospace Engineering, Indian Institute of Technology, Kharagpur-721302, India; Ctr. Math. Modelling/Comp. Simulat., Bangalore-560017, India	Smart Materials and Structures, 2004, 13(4)	59

resolves it. They classify constraint formulations into true physical limits and artificial, discretisation-induced spurious constraints that cause over-stiffening, showing that reduced integration selectively removes these spurious terms.

The second most cited paper is titled "Galerkin finite element method for non-linear beam vibrations (132 citations) by Prathap, G. and Bhashyam, G.R., published in the *Journal of Sound and Vibration* in 1980 (Bhashyam and Prathap, 1980). The authors present a successful finite element formulation using only the transverse displacement term to analyse large-amplitude, non-linear beam vibrations. The study demonstrates two techniques for solving the resulting nonlinear eigenvalue problem

and proves that the governing differential equations do not allow space-time solutions.

DISCUSSION

Dr Prathap's 126 publications highlight his regular publication output and impactful contributions during 1975-2010. His peak productivity phase (accounted for 39.68% of his total output) was during 1976-1980. He published the most papers in 1976 (15 papers, 11.90%). His research moved from single-author publications (22.22%) to multi-authored collaborations (77.78%), indicating a shift towards team-based research. His contributions are largely in journal articles (98.41%), with predominant dissemination across 30 different sources. Among 28 journals publishing his research, International Journal of Numerical Methods in Engineering contributed 26 papers, followed by Computers and Structures (25 papers), and Journal of Sound and Vibration (20 papers). The 44.72% and 46.34% of his output was published in 15 and 9 medium IF (2.3 to 3.8) and high impact factor IF (4.5-24.2) journals.

His primary institutional affiliation is the National Aerospace Laboratory, Bangalore, contributing 72 papers with notable collaborations involving C-MMCS, Bangalore (52 papers), Indian Institute of Technology, Madras (23), and Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore (5 papers) (Singh and Gupta, 2010).

The co-authorship network of Dr Prathap was a strong co-authorship network, indicating his extensive collaboration with 43 authors, 10 institutions, and 5 countries. His most frequent institutional collaborations involve C-MMCS, Bangalore-National Aeronautical Laboratory, Bangalore (17 papers), National Aeronautical Laboratory, Bangalore-Indian Institute of Technology, Madras (10 papers) and C-MMCS, Bangalore-Indian Institute of Technology (IIT), Kharagpur (8 papers). The most frequent collaborators are M. T.K. Varadan (23 papers), B.P. Naganarayana (10 papers), C.R. Babu and S. Raja (8 papers each), P.K. Sinha (7 papers), G.R. Bhashyam (5 papers), P. Jafarali, R.U. Vinayak, V. Senthilkumar, and B.R. Somashekar BR (4 papers each), reflecting extensive teamwork and knowledge exchange (Singh and Gupta, 2010). His research output (126) has accumulated a total of 2.514 citations over the years, with an average of 19.95 citations per paper, demonstrating significant academic influence (Chang and Liu, 1996;(Nabavi, 2024).

CONCLUSION

This study highlights Dr Prathap's pioneering contributions, strong research collaborative engagement, and sustained publication output, strong citation impact and thematic focus in specific research domains. The present bibliometric study focuses on Dr Prathap's research contributions covered only in the Scopus Database; however, his future research should use multiple publication and citation sources to provide a more comprehensive picture of his publication and citation impact assessment. The findings demonstrate that his non-linear structural and computational mechanics research has evolved into a significant component of Dr Gangan Prathap's scholarly portfolio, paralleling his growing global interest in bibliometrics research.

ABBREVIATIONS

ADA: Aeronautical Development Agency; **AIAA:** American Institute of Aeronautics and Astronautics; **ASME:** American Society of Mechanical Engineers; **CC:** Collaboration Coefficient; **C-MMACS:** CSIR Centre for Mathematical Modeling and Computer Simulation; **CPP:** Citations Per Paper; **CR:** Collaboration Rate; **CSIR:** Council of Scientific and Industrial Research; **DAAD:** Deutscher Akademischer Austauschdienst (German Academic Exchange Service); **DESIDOC:** Defence Scientific Information and Documentation Centre; **DFVLR:** Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt (German Research and Testing Institute for Aviation and Space Flight); **DRDL:** Defence Research and Development Laboratory; **FEM:** Finite Element Method; **FEPACS:** Finite Element Package for Analysis of Composite Structures; **HAL:** Hindustan Aeronautics Limited; **HCPs:** Highly Cited Papers; **ICPs:** International Collaborative Publications; **IISc:** Indian Institute of Science; **IIT:** Indian Institute of Technology; **IF:** Impact Factor; **JNCASR:** Jawaharlal Nehru Centre for Advanced Scientific Research; **NAL:** National Aerospace Laboratories; **NIIST:** National Institute for Interdisciplinary Science and Technology; **NISCAIR:** National Institute of Science Communication and Information Resources; **NISTADS:** National Institute of Science, Technology and Development Studies; **NITC:** National Institute of Technology Calicut; **NITIE:** National Institute of Industrial Engineering; **OCC:** Occurrence Count; **ORCID:** Open Researcher and Contributor ID; **Q:** Quartile Ranking; **RCI:** Relative Citation Index; **SAARC:** South Asian Association for Regional Cooperation; **TC:** Total Citations; **TLS:** Total Link Strength; **TP:** Total Publications.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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