

Structural Integrity 23

Series Editors: José A. F. O. Correia · Abilio M. P. De Jesus

Shahrum Abdullah
Salvinder Singh Karam Singh
Noorsuhada Md Nor *Editors*

Structural Integrity Cases in Mechanical and Civil Engineering

 Springer

Structural Integrity Cases in Mechanical and Civil Engineering

Editors: Shahrum Abdullah, Salvinder Singh Karam Singh, Noorsuhada Md Nor

Shahrum Abdullah · Salvinder Singh Karam Singh ·
Noorsuhada Md Nor
Editors

Structural Integrity Cases in Mechanical and Civil Engineering

 Springer

Editors

Shahrum Abdullah
Faculty of Engineering and Built
Environment
Universiti Kebangsaan Malaysia
UKM Bangi, Selangor, Malaysia

Salvinder Singh Karam Singh
Faculty of Engineering and Built
Environment
Universiti Kebangsaan Malaysia
UKM Bangi, Selangor, Malaysia

Noorsuhada Md Nor
Civil Engineering Studies
Universiti Teknologi MARA
Cawangan Pulau Pinang
Permatang Pauh, Malaysia

ISSN 2522-560X

ISSN 2522-5618 (electronic)

Structural Integrity

ISBN 978-3-030-85645-8

ISBN 978-3-030-85646-5 (eBook)

<https://doi.org/10.1007/978-3-030-85646-5>

© The Editor(s) (if applicable) and The Author(s), under exclusive license to Springer Nature Switzerland AG 2022

This work is subject to copyright. All rights are solely and exclusively licensed by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Preface

Structural integrity is a scientific area that studies the integrity of a support structure taking into account the structural loads for which the structure was designed, but also taking into account the loads operated during the life of the structure. Besides, this discipline studies past structural failures to be taken into account in structural assessments of existing engineering structures as well as in future designs.

Structural integrity and failure analysis include a set of topics for structural assessments to be developed such as: structural integrity, failure analysis, structural durability, degradation and conservation of materials and structures, dynamic and seismic structural analysis, fatigue and fracture of materials and structures, risk analysis and safety of materials and structural mechanics, fracture mechanics, damage mechanics, analytical and numerical simulation of materials and structures, computational mechanics, structural design methodology, experimental methods applied to structural integrity, multiaxial fatigue and complex loading effects of materials and structures, fatigue corrosion analysis, scale effects in the fatigue analysis of materials and structures, fatigue structural integrity, structural integrity in railway and highway systems, sustainable structural design, structural loads characterization, structural health monitoring, adhesives connections integrity, rock and soil structural integrity, etc.

The 5th Symposium on Damage Mechanism in Materials and Structures (SDMMS 2021) took place in Universiti Teknologi MARA, Cawangan Pulau Pinang, Malaysia on 8–9 March 2021. This symposium provided a venue for researchers and engineers in damage mechanisms in the materials and structures field from academia, industry, and government to meet in a forum where the latest research results are presented and prospects for future developments are discussed. The symposium was organized by the Universiti Teknologi MARA (UiTM) Cawangan Pulau Pinang, Faculty of Civil Engineering and Universiti Kebangsaan Malaysia (UKM), Computational and Experimental Mechanics (CEM) Research Group. This event was the fifth in a series of conferences that started in August 2016, Malaysia. The 1st Symposium on Damage Mechanisms in Materials and Structures (SDMMS), 2016, was organized by the Universiti Kebangsaan Malaysia (UKM), Centre for Automotive Research (CAR),

Faculty of Engineering and Built Environment, Malaysian Association of Computational Mechanics (MACM), and Universiti Malaysia Perlis (UniMAP). The 2nd Symposium on Damage Mechanisms in Materials and Structures (SDMMS), 2017, took place in Hotel Bangi-Putrajaya, Bandar Baru Bangi, Selangor on October 24th, 2017. The 3rd SDMMS were held in Hotel Bangi-Putrajaya, Bandar Baru Bangi, Selangor, in 2018. The 4th SDMMS which were held in Hotel Bangi-Putrajaya, Bandar Baru Bangi, Selangor on October 20–22th, 2019.

This volume of the Structural Integrity series with 24 chapters covers the subject related to the damage mechanism and structural integrity in the scope of mechanical engineering and civil engineering. Thus, the failure pattern of various materials and structures in both engineering field was agreed upon as the main subject matter for the discussion. The topics approached are in the scope of fatigue damage, fatigue crack initiation and propagation, life prediction techniques, computational fracture mechanics, dynamic fracture, damage mechanics and assessment, Non-Destructive Test (NDT), concrete failure assessment, failure on soil structures, structural durability and reliability, structural health monitoring, construction damage recovery, and any relevant topics related to failure analysis. The book is suitable for those who involve in this field, such as academicians, engineers, practitioners, students, and researchers. They are the main players who want to obtain an up to date view of the recent advances in the area of damage mechanisms in both the engineering field of mechanical and civil.

The keynote lectures of the 5th SDMMS 2021 were given by: Prof. Ir. Dr. Ahmad Kamal Ariffin Mohd. Ihsan of the Universiti Kebangsaan Malaysia, Malaysia; Associate Prof. Dr. Wonsiri Punurai of the Mahidol University, Thailand; Ir. Hambali Chik of the Petroliaam Nasional Berhad (PETRONAS); Dato' Ir. Dr. Goh Teik Cheong of the M.E.I. Project Engineers Sdn Bhd; and Dr. Musa Bashir of the Liverpool John Moores University, England.

The chairman of the 5th SDMMS, Prof. Shahrum Abdullah (Universiti Kebangsaan Malaysia), acknowledges all authors who have contributed to the success of the event and their contributions to this volume dedicated to the structural integrity cases in civil and mechanical engineering, as well as the organizers, sponsors, scientific committee for their support. Also, Springer is fully acknowledged for its support to this volume.

UKM Bangi, Malaysia
Porto, Portugal
UKM Bangi, Malaysia
Porto, Portugal
May 2021

Shahrum Abdullah
José A. F. O. Correia
Salvinder Singh Karam Singh
Abílio M. P. De Jesus

Contents

1	A Review of Shear Wall Location Response in High-Rise RCC Structures as a Result of Earthquake Effect	1
	Shamilah Anuda, Nasr Abdullah Abdulrahman, and Nik Zainab Nik Azizan	
2	LCO Flutter Instability on Oscillating Supersonic Wing by Means of Linearized Aerodynamic Small Disturbance Theory	13
	Nur Azam Abdullah, Erwin Sulaeman, and Meor Iqram Meor Ahmad	
3	Peridynamic Method for Behaviour of Polycarbonate Specimen in Impact Test	29
	M. A. Azizi, A. A. Fahad, and S. A. Rahim	
4	Enhancement of Mechanical Properties for AZ31B Quenching in Nano Fluid	45
	M. M. Mubasyir, M. F. Abdullah, K. Z. Ku Ahmad, R. N. I. R. Othman, and A. H. Isahak	
5	Comparison of Lattice Structure Configurations for Suitability in Turbine Blades Using Modal and Harmonic Response Analysis	57
	Sajjad Hussain, Wan Aizon W. Ghopa, Salvinder Singh, Abdul Hadi Azman, Shahrum Abdullah, and Hafizan Kamaruddin	
6	Systematic Review: Overview on Trends and Future Opportunities of Additive Manufactured Lattice Structures	75
	Asliah Seharng, Abdul Hadi Azman, and Shahrum Abdullah	
7	Review on Coastal Liquefaction at Sabah Bays	91
	Noor Sheena Herayani Harith, Isabella Boy Setanis, Ejria Saleh, and Tze Liang Lau	

8	Ground Motion Prediction Equations for Sabah Region	101
	Noor Sheena Herayani Harith, Nur Afifah Kassim, Samnursidah Samir, and Azlan Adnan	
9	Fatigue Detection on Glass Fibre Reinforced Polymer Material Using Fiber Bragg Grating Sensor	115
	Miminorazeansuhaila Loman and Mohd Hafizi Zohari	
10	Biomechanical Overloading Factors Influencing the Failure of Dental Implants: A Review	127
	Muhammad Ikman Ishak, Ruslizam Daud, Ishak Ibrahim, Fauziah Mat, and Nurul Najwa Mansor	
11	Sensitivity Creep Simulation for the Equipment's Component Experiencing Extreme Elevated Temperature	143
	Hashim Othman, Nurul Hana Kamaruzaman, and Ir. Hambali Chik	
12	Characterization of Fatigue and Crack Growth on AZ31B Magnesium Alloy	155
	A. H. Isahak, M. F. Abdullah, M. K. Faidzi, Aidy Ali, and M. M. Mubasyir	
13	The Effects of Mean Strain on the Fatigue Life of the SAE 1541 Carbon Steel Based on the Strain-Life Approach	171
	Teuku Edisah Putra, Husaini, and Rauzatul Akmal	
14	Mechanical Characteristics of Fly Ash-Based Geopolymer Bricks	185
	Mahfodzah Md Padzi, Nor Sarah Zahir, and Mohd Ridzuan Mohd Ali	
15	Effect of Bio Lubricants on the Dynamic Performance of Rotor Bearing System: A Mathematical Model	195
	Muhammad Imran Sadiq, Wan Aizon Wan Ghopa, Mohd Zaki Nuawi, Mohammad Rasidi Mohammad Rasani, and Tajammal Imran	
16	Experimental Investigation of Acoustic Emission Characteristics at Different Type of Sensors for Granite	209
	Noorsuhada Md Nor, Khairul Afinawati Hashim, Shahrum Abdullah, and Nur Fazlinieza Khairosam	
17	Seismic Excitations of Prefabricated Reinforced Concrete Building Performance: Case Study of Kolej Delima Universiti Teknologi MARA, Cawangan Pulau Pinang	223
	Mohd Samsudin Abdul Hamid, Norul Mas Diyana Ahmad, Kay Dora Abd Ghani, Siti Hafizan Hassan, and Nurulzatushima Abdul Karim	

18 The Effects of Peat Modified Asphalt Binder Concentrations on Viscoelastic Properties 239
 Ahmad Suliman B. Ali, Mohd Idrus Mohd Masirin,
 Abdalrhman Milad, Allam Musbah Al Allam,
 and Nur Izzi Md Yusoff

19 Experimental Assessment of Steel Fibre Reinforced Concrete Beam Strengthened with Carbon Fibre Reinforced Polymer 253
 Noorsuhada Md Nor, Abdul Hakeem Zulkifli,
 Soffian Noor Mat Saliah, Noor Syafeekha Mohamad Sakdun,
 Nor Z. Amin, Nor N. A. Anisah, and Azmi Ibrahim

20 Simulation of Structural Analysis on Fatigue Crack (Isotropic) in FRP Laminate 267
 Roslin Ramli, Mohd Hisbany Mohd Hashim,
 Suhailah Mohamed Noor, Anizahyati Alisibramulisi,
 and Muhammad Azrie Husainy Mohd Jasri

21 Managing Damages Recovery: Adopting Green Road Operation and Maintenance Index Criteria 277
 Jeffryl Azniel Adzar, Rozana Zakaria, Eeydzah Aminudin,
 Dayalan Rainoo Raj, Rozelawati Ishak,
 Mohamad Faizal Sahadan, Ridzuan Mohd Radzi,
 Mohamad Hafizudin Syafiq Abd Rashid, Vikneswaran Munikan,
 Siti Mazzuana Shamsudin, and Sherliza Zaini Sooria

22 Building Defects Assessment Framework for Malaysian Construction Projects 297
 Siti Hafizan Hassan, Mohd Samsudin Abdul Hamid,
 Mohd Faisal Zaini, Syahrul Fithry Senin, Zulfairul Zakariah,
 and Mohamad Zain Hashim

23 CO₂ Emission and Cost Estimates of Wastepaper Sludge Ash in Controlled Low-Strength Material Towards Sustainability 313
 Mohd Azrizal Fauzi, Mohd Fadzil Arshad, Noorsuhada Md Nor,
 and Noor Idayani Noordin

24 Acoustic Emission Characterisation of Reinforced Concrete Beam at an Initiation Stage of Fatigue Damage 327
 N. M. Nor, S. N. Mat Saliah, M. S. Tahir, and N. A. Yahya

Fatigue Detection on Glass Fibre Reinforced Polymer Material Using Fiber Bragg Grating Sensor

[Miminorazeansuhaila Loman](#)  & [Mohd Hafizi Zohari](#)

Conference paper | [First Online: 24 January 2022](#)

89 Accesses

Part of the [Structural Integrity](#) book series (STIN, volume 23)

Abstract

The effectiveness of monitoring systems for composite materials is improving owing to their increasing utilisation. Abrupt failure in composite requires an effective detection method and monitoring system. The fibre Bragg grating (FBG) sensor is one of the alternative sensors used for detecting and monitoring the structural health of an engineering structure. This study evaluated the applicability of the FBG sensor for fatigue damage monitoring in the composite. This study involved composite fabrication and experimental work. The glass fibre reinforced polymer specimens were fabricated using fibre glass and resin and made into flat workpieces. The workpieces were then utilised in a series of fatigue tests. Prior to the fatigue test, tensile tests were conducted to verify the ultimate strength of the material. Commencement of fatigue tests were recorded using the FBG sensor. Once the tests were started, the signals were acquired using the FBG sensor simultaneously. Data acquisition was continued during the fatigue test progression until the specimen failed. Results show the FBG wavelength shifted from its original position during tension loading and whenever the composite was released to its original position in the cyclic test. The FBG sensor seems a promising way to monitor fatigue damage and can be utilised in fatigue monitoring. Its wavelength shifts or changes is capable to monitor fatigue damage progression effectively.

Keywords

Fatigue

Fibre bragg grating

Composite

References

1. Gude M, Hufenbach W, Koch I, Koschichowa R, Schulte K, Knoll J (2013) Fatigue testing of carbon fibre reinforced polymers under VHCF loading. *Proc Mater Sci* 2:18–24

[CrossRef](#) [Google Scholar](#)

2. Adam TJ, Horst P (2014) Experimental investigation of the very high cycle fatigue of GFRP [90/0]_s cross-ply specimens subjected to high-frequency four-point bending. *Compos Sci Technol* 101:62–70

[CrossRef](#) [Google Scholar](#)

3. Gardyński L, Caban J, Barta D (2018) Research of composite materials used in the construction of vehicle bodywork. *Adv Sci Technol Res J* 12(3)

[Google Scholar](#)

4. Patel M, Pardhi B, Chopara S, Pal M (2018) Lightweight composite materials for automotive—a review. *Int Res J Eng Technol (IRJET)* 5(11)

[Google Scholar](#)

5. Suresh S (2001) *Fatigue of materials*, 2nd edn. Cambridge University Press

[Google Scholar](#)

6. Ferdous W, Manalo A, Peauril J, Salih C, Reddy KR, Yu P, Schubel P, Heyer T (2020) Test and modelling the fatigue behavior of GFRPR. *Composites—effect of stress level, stress concentration and frequency. Eng Sci Technol Int J* 23(5):1223–1232

[Google Scholar](#)

7. Tanimoto T, Amijima S (1975) Progressive nature of fatigue damage of glass fiber reinforced plastics. *J Compos Mater* 9:380–390

[CrossRef](#) [Google Scholar](#)

8. Kocaman ES, Akay E, Yilmaz C, Turkmen HS, Misirlioglu IB, Suleman A, Yildiz MT (2017) Monitoring the damage state of fiber reinforced composites using an FBG network for failure prediction. *Materials* 10(32):1–19

[Google Scholar](#)

9. Glisic B, Chen J, Hubbell D, Streicker B (2011) A comparison between Bragg-gratings long-gauge strain and temperature sensors and Brillouin scattering-based distributed strain and temperature sensors. In: Proceedings of SPIE 7981. <https://doi.org/10.1117/12.881818>

10. Garcea SC, Spearing SM, Sinclair I (2012) Exploring the fundamental of fatigue in composites: opportunities using x-ray computed tomography imaging. Air Force Research Laboratory annual report, University of Southampton, United Kingdom

[Google Scholar](#)

11. Mouritz AP, Townsend C, Shah Khan MZ (2000) Non-destructive detection of fatigue damage in thick composites by pulse-echo ultrasonics-ultrasonic and SEM evaluations. *Compos Sci Technol* 60(1):23–32

[CrossRef](#) [Google Scholar](#)

12. Colombo C, Libonati F, Vergani L (2012) Fatigue damage in GFRP. *Int J Struct Integr* 3(4):424–440

[CrossRef](#) [Google Scholar](#)

13. Wang P, Takagia T, Takenob T, Miki H (2013) Early fatigue damage detecting sensors—a review and prospects. *Sens Actuators A Phys* 198:46–60

[CrossRef](#) [Google Scholar](#)

14. Karimian SF, Modarres M, Bruck HA (2020) A new method for detecting fatigue crack initiation in aluminum alloy using acoustic emission waveform information entropy. *Eng Fract Mech* 223(106771):1–12

[Google Scholar](#)

15. Papazian JM, Nardiello J, Silberstein RP, Welsh G, Grundy D, Craven C, Evans L, Goldfine N, Michaels JE, Michaels TE, Li Y, Laird C (2007) Sensors for monitoring early stage fatigue cracking. *Int J Fatigue* 29:1668–1680

[CrossRef](#) [Google Scholar](#)

16. Belhouideg S, Lagache M (2018) Effect of embedded strain gage on the mechanical behavior of composite structures. *J Modern Mater* 5(1):1–7

[CrossRef](#) [Google Scholar](#)

17. Liu B, Zhang S, Jianping HE (2019) Deformation measurement of glass structure using FBG sensor. *Photonic Sens* 9(6)

[Google Scholar](#)

18. Guo X, Wang B, Ma Z, Wang Z (2019) Testing mechanical properties of rock bolt under different supports using fiber bragg grating technology. *Sensors* 19(4098).
<https://doi.org/10.3390/s19194098>

19. Claire D, Silvia T, Ivan G, James K, Travis N (2012) High-strain fiber bragg gratings for structural fatigue testing of military aircraft. *Photonic Sens* 2(3):215–224

[CrossRef](#) [Google Scholar](#)

20. Arena M, Viscardi M (2020) Strain state detection in composite structures: review and new challenges. *J Compos Sci* 4(60). <https://doi.org/10.3390/jcs4020060>

21. Sahota JK, Gupta N, Dhawan D (2020) Fiber Bragg Grating sensor for monitoring of physical parameters: a comprehensive review. *Opt Eng* 59(6):060901–060935

[CrossRef](#) [Google Scholar](#)

22. Werneck MM, Allil RCSB, Ribeiro BA, de Nazaré FVB (2013) A Guide to fiber bragg grating sensors, current trends in short and long-period fiber gratings. In: Cuadrado-Laborde C (ed) IntechOpen, pp 1–24

[Google Scholar](#)

23. Rao MB, Bhat MR, Murthy CRL, Madhav KV, Asokan S (2006) Structural health monitoring (SHM) using strain gauges, PVDF film and fiber bragg grating (FBG) sensors: a comparative study. In: Proceedings of national seminar on non-destructive evaluation, 7–9 Dec, Hyderabad

[Google Scholar](#)

Author information

Authors and Affiliations

Advanced Structural Integrity & Vibration Research, Faculty of Mechanical & Automotive Engineering, Universiti Malaysia Pahang, 26600, Pekan, Pahang, Malaysia

Miminorazeansuhaila Loman & Mohd Hafizi Zohari

Corresponding author

Correspondence to [Miminorazeansuhaila Loman](#).

Editor information

Editors and Affiliations

Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, UKM Bangi, Selangor, Malaysia

Prof. Dr. Shahrum Abdullah

Faculty of Engineering and Built Environment, Universiti Kebangsaan Malaysia, UKM Bangi, Selangor, Malaysia

Dr. Salvinder Singh Karam Singh

Civil Engineering Studies, Universiti Teknologi MARA, Cawangan Pulau Pinang, Permatang Pauh, Malaysia

Assoc. Prof. Noorsuhada Md Nor