行政院所屬各機關因公出國人員出國報告書
（出國類別：出席國際會議）

出席 21st International Conference on Composite Materials (ICCM-21)

研討會議報告

出國人
服務機關 ：國立臺北科技大學
職　　稱：計畫主持人、研究員
姓　　名：鄭大偉、李韋皞

出國地點：中國陝西省西安市曲江國際會議中心
出國期間：106 年　8 月　21 日至 25 日
報告日期：106 年　8 月　25 日

摘要

The ICCM, having started in 1975, is the largest conference series dedicated to composite materials. ICCM21 has adopted the motto of ‘Advanced Composites: Innovation and Development’, bringing together researchers, scientists and practitioners worldwide to explore the role of innovation in the development of composites, and the impact on global economy.

The themes for ICCM-21 will contain all the composite materials with relate to researches and applications, including but not limited to Materials Science, Structural Design, Experimental Methods, Mechanical Properties, Multifunctional and Smart Composites, Processing and Manufacturing, Applications. The scientific program will consist of plenary talks, keynote lectures, mini-symposia, oral sessions and poster sessions.

目錄

會議報告

壹、 會議名稱

此會議名稱為: 21st International Conference on Composite Materials (ICCM-21)。

貳、會議時間

會議時間自 106 年 8 月 21 日至 8 月 25 日，共計 5 日。

參、會議地點

ICCM-21 之會議舉辦地點為中國陝西省西安市曲江國際會議中心。

肆、參與會議目的：

本研討會係由國際複合材料學會所主辦，研討會主要係提供各種複合材料相關領域之研究學者，分享成果及研究構想之平台。研討會內容包括:材料工程、結構設計、實驗設計法、機械性質、多功能及智能複合材料、加工製造工程、高分子纖維、綠能材料。本次研討會之口頭發表文章數量約為 1600 篇，海報發表數量約為 500 篇。

伍、會議議程與經費：

一、會議議程

106 年 8 月 21 日（星期一）

08:40 開幕典禮

09:10-10:00 主題演講

10:15-10:50 主題演講

10:50-11:10 中場休息

11:10-12:50　口頭報告-1

12:50-13:50　午餐

13:50-14:40　主題演講

14:55-15:30　主題演講

15:30-15:50　中場休息

15:50-17:10　口頭報告-2

17:10-18:30　口頭報告-3

18:30　本日會議結束

106 年 8 月 22 日（星期二）

08:00-08:50　主題演講

09:05-10:25　口頭報告-1

10:25-10:50　中場休息

10:50-11:25　主題演講

11:35-12:35　口頭報告-2

12:35-13:35　午餐

13:35-14:25　主題演講

14:40-15:15　主題演講

15:15-15:40　中場休息

15:40-17:00　口頭報告-3

17:00-18:20　口頭報告-4

18:20　本日會議結束

106 年 8 月 23 日（星期三）

08:00-08:50　主題演講

09:05-11:45　迷你口頭報告-1

11:45-12:35　海報展示

12:35-13:35　海報展示和午餐

13:35-14:25　主題演講

14:40-15:15　主題演講

15:15-15:35　中場休息

15:35-16:55　口頭報告-1

17:00-18:20　大會展覽

18:20　本日會議結束

106 年 8 月 24 日（星期四）

08:00-08:50　主題演講

09:05-10:25　口頭報告-1

10:25-10:50　中場休息

10:50-11:25　主題演講

11:35-12:35　口頭報告-2

12:35-13:35　午餐

13:35-14:25　主題演講

14:40-15:15　主題演講

15:15-15:40　中場休息

15:40-17:00　口頭報告-3

17:00-18:20　口頭報告-4

18:20　本日會議結束

106 年 8 月 25 日（星期五）

08:00-08:50　主題演講

09:05-10:25　口頭報告-1

10:25-10:50　中場休息

10:50-11:25　主題演講

11:35-12:35　口頭報告-2

12:35-13:35　午餐

13:35-14:25　主題演講

14:25-14:50　中場休息

14:50-16:30　口頭報告-3

16:30　本日會議結束

（詳細會議議程如附件一所示）

二、會議經費

本次赴中國陝西省西安市參與 21st International Conference on Composite Materials 會議行程之國外差旅費包含機票、日支生活費及研討會報名費…等。其中與會 2 人之機票總金額為新台幣 29,000 元整為桃園直飛西安市來回機票；生活日支費共支用新台幣 38,812 元整；研討會報名費為新台幣 30,899 元整，以上相關研討會支出費用共計為新台幣 98,711 元整。

陸、研討會議紀要

1. Keynote 1: Yiu-Wing Mai, University of Sydney, Australia
2. Keynote 2: Fu-Kuo Chang, Stanford University, USA
3. Keynote 3: Debes Bhattarcharyya, University Auckland, New Zealand
4. Keynote 4: Dongsheng Li, Commercial Aircraft Corporation of China, China
5. Keynote 5: Stephen Tsai, Stanford University, USA
6. Keynote 6: Liqun Zhang, Beijing University of Chemical Technology, China
7. Keynote 7: Kon-Well Wang, University of Michigan, USA
8. Keynote 8: Soon Hyung Hong, Korea Advanced Institute of Science and Technology, Korea
9. Keynote 9: Tongyi Zhang, Shanghai University, China
10. Keynote 10: Woo Il Lee, Seoul National University, Korea
11. Keynote 11: Norman Wereley, University of Maryland, USA
12. Keynote 12: Ozden Ochoa, Texas A&M University, USA
13. Keynote 13: Tsu-Wei Chou, University of Delaware, USA
14. Keynote 14: Leif Asp, Luleå University of Technology, Sweden
15. Keynote 15: Andy Long, The University of Nottingham, UK
16. Keynote 16: Alan KT Lau, Swinburne University of Technology, Australia
17. Keynote 17: Huiming Cheng, Institute of Metal Research, Chinese Academy of Sciences, China
18. Keynote 18: Michael Wisnom, University of Bristol, UK
19. Keynote 19: Jian Lu, City University of Hong Kong, China
20. Keynote 20: Byung Sun Kim, Korea Institutes of Material Science, Korea
21. Keynote 21: Brian G. Falzon Queen's University Belfast, UK
22. Keynote 22: Ray Baughman, University of Texas at Dallas, USA
23. Keynote 23: Anthony M. Waas, University of Washington, USA

24. Keynote 24: Jang Kyo Kim, The Hong Kong University of Science and Technology, China
25. Keynote 25: Véronique Michaud, Ecole Polytechnique Fédérale de Lausanne, Switzerland
26. Keynote 26: Zhongmin Xue, Sinoma Science & Technology Co., Ltd, China
27. Keynote 27: Christopher S. Lynch, University of California, Los Angeles, USA
28. Keynote 28: Chiara Bisagni, Delft University of Technology, Netherlands;
29. Keynote 29: Milo Shaffer, Imperial College London, UK
30. Keynote 30: Daniel J. Inman, University of Michigan, USA
31. Keynote 31: Zhishen Wu, Southeast University, China Yoshihiro Narita, Hokkaido University, Japan
32. Keynote 32: Zhengming Huang, Tongji University, China
33. Keynote 33: HeeJune Kim, LG Hausys R&D Center, Korea

柒、發表文章摘要

Greenhouse effect is an important topic since it has been responsible for global warming. Carbon dioxide also plays a part of role in the greenhouse effect. Therefore, human has the responsibility of reducing CO2 emissions in their daily operations. Except iron making and power plants, another major CO2 production industry is the cement industry. Estimation by EPA of Taiwan, production 1 ton of cement will produce 520.29 kg carbon dioxide. There are 7.8 million tons of CO2 produced annually. Thus, to synthesize low CO2 emission geopolymeric green cement is important and can reduce CO2 emission problems in Taiwan.

The purpose of this study is trying to use marble wastes as the raw material to fabricate geopolymer green cement. Experiment results show that the setting time of green cement was exceed 4 hours. After curing 28 days, the compressive strength of marble based geopolymer green cement paste can reach 65 MPa, that is higher than traditional Portland Cement.This study is based on resource recovery and recycling. Its basic characteristics are low consumption, low emission and high efficiency that meet the Taiwan government’ s policy of "Circular Economy", and this is an international tendency.

According to experimental results, the marble-based geopolymer green cement can be developed as a low CO2 emission green cement. By comparing with Portland cement paste, production 1 ton of marble-based geopolymer green cement paste, it can be saved around 53.8% carbon dioxide emission. Production 1 ton of green cement paste will cost about 1350 NTD (~42 USD) that cheaper than traditional Portland cement paste. It is proved that the green cement has very good potential for further engineering development in the future.

捌、心得與建議

台灣目前人均碳排放量為全球排名第22名，水泥業是碳排放量高的生產工業之一，水泥生產的過程會消耗大量的能量，並不符合現代節能減碳之趨勢。無機聚合材料具有高早期強度、常溫硬化、隔熱性質佳、抗酸鹼及耐久性佳等優點。以無機聚合材料之基礎取代傳統水泥，能有效降低能量的消耗及二氧化碳排放量，可視為新一代之綠色環保再生材料。

本次發表之研究主題係以大理石及爐石粉為基材，再與鹼液混拌，常溫下即可製成無機聚合材料。研究結果顯示，當鹼液 SiO_2/Na_2O 莫耳比為1.28，大理石與爐石粉以6:4之比例，液固比為0.4，其硬化時間可超過4小時，其抗壓強度可達65MPa；於大理石基無機聚合水泥中，添加矽灰石，可以有效改善其收縮之問題。使用大理石基無機聚合水泥時，能有效減少二氧化碳之排放量。

於會議過程中，看到世界各國，包含台灣、美國、中國、日本、韓國...等國家，許多研究單位致力於各類型之複合材料研究，且認識到其他國家之研究單位，已將自我研究之技術，成功推廣至市場上，實為大開眼界，但於此同時也感受到台灣國內之不足，期望能於未來與各國密切互動後，逐漸建立起屬於台灣自己的技術研發團隊。

附件一、會議議程

Dates	Time Slot	ROOM 1 (Presidium Conference Room)	ROOM 2 (402)	ROOM 3 (406)	ROOM 4 (405)	ROOM 5 (305)	ROOM 6 (International Reporting Hall)	ROOM 7 (VIP 303)	ROOM 8 (VIP 304)	ROOM 9 (306)	ROOM 10 (308)	ROOM 11 (311)	ROOM 12 (313)	ROOM 13 (204)	ROOM 14 (205)	ROOM 15 (206)	ROOM 16 (207)	ROOM 17 (208)	ROOM 18 (VIP 101)	ROOM 19 (VIP 102)	ROOM 20 (VIP 105)	ROOM 21 (VIP 106)	ROOM 22 (209+210)
	8:40-9:10	Opening Ceremony																					
	9:10-10:00	SCALA LECTURE by: Yiu-Wing Mai, University of Sydney, Australia - Personal Reflections on a Career of Composite Materials Research: A Matter of Opportunities																					
	10:15-10:50	KEYNOTE LECTURE by: 1) Fu-Kuo Chang, Stanford University, USA; 2) Debes Bhattacharyya, University Auckland, New Zealand; 3) Dongsheng Li, Commercial Aircraft Corporation of China, China																					
	10:50-11:10	Coffee Break																					
	11:10-12:50	1101 Polymer Matrix Materials 1	1102 Metal Matrix Composites 1	1103 Fiber-reinforced Composites 1	1104 Fracture and Damage 1	1105 Nano-Composites 1	1106 Ceramic Matrix Composites 1	1107 Structural Analysis and Optimization 1	1108 Multiscale Modelling of Structures 1	1109 Bio-Composites 1	1110 Durability, Creep and Aggressive Environment 1	1111 Hybrid Composites 1	1112 Office Naval Research (ONR) Session 1	1113 Joints 1	1114 Composite Structures 1	1115 Fatigue 1	1116 Stimuli Responsiveness and Shape Reconfiguration 1	1117 Design and Manufacture for Multifunctionality 1	1118 Interfaces and Interphases 1	1119 Coupled Properties and Multi-Physics Models	1120 Digital Image 1	1121 Aerospace 1	
Monday 21 August	12:50-13:50	Lunch																					
	13:50-14:40	PLENARY LECTURE by: Stephen Tsai, Stanford University, USA - Design of Composite Laminates																					
	14:55-15:30	KEYNOTE LECTURE by: 1) Liqun Zhang, Beijing University of Chemical Technology, China; 2) Kon-Well Wang, University of Michigan, USA; 3) Soon Hyung Hong, Korea Advanced Institute of Science and Technology, Korea																					
	15:30-15:50	Coffee Break																					
	15:50-17:10	1201 Polymer Matrix Materials 2	1202 Metal Matrix Composites 2	1203 Fiber-reinforced Composites 2	1204 Fracture and Damage 2	1205 Nano-Composites 2	1206 Ceramic Matrix Composites 2	1207 Structural Analysis and Optimization 2	1208 Multiscale Modelling of Structures 2	1209 Bio-Composites 2	1210 Durability, Creep and Aggressive Environment 2	1211 Hybrid Composites 2	1212 Office Naval Research (ONR) Session 2	1213 Joints 2	1214 Composite Structures 2	1215 Fatigue 2	1216 Stimuli Responsiveness and Shape Reconfiguration 2	1217 Design and Manufacture for Multifunctionality 2	1218 Interfaces and Interphases 2	1219 Recycling of Composites and Sustainability 1	1220 Digital Image 2	1221 Aerospace 2	Process Induced Effects - Workshop: International Benchmark Exercises on Textile Permeability and Compressibility Characterization
	17:10-18:30	1301 Polymer Matrix Materials 3	1302 Metal Matrix Composites 3	1303 Fiber-reinforced Composites 3	1304 Fracture and Damage 3	1305 Nano-Composites 3	1306 Ceramic Matrix Composites 3	1307 Structural Analysis and Optimization 3	1308 Multiscale Modelling of Structures 3	1309 Bio-Composites 3	1310 Moire and Grid Based Technique	1311 Hybrid Composites 3	1312 Office Naval Research (ONR) Session 3	1313 Joints 3	1314 Composite Structures 3	1315 Fatigue 3	1316 Stimuli Responsiveness and Shape Reconfiguration 3	1317 Design and Manufacture for Multifunctionality 3	1318 Interfaces and Interphases 3	1319 Recycling of Composites and Sustainability 2	1320 Bio and Medical 1	1321 Aerospace 3	
	18:40-21:30	Welcome Reception																					
	8:00-8:50	PLENARY LECTURE by: Tongyi Zhang, Shanghai University, China - Brief Introduction to Materials Genome Initiative and Materials Informatics																					
	9:05-10:25	2101 Polymer Matrix Materials 4	2102 Metal Matrix Composites 4	2103 Fiber-reinforced Composites 4	2104 Fracture and Damage 4	2105 Nano-Composites 4	2106 Ceramic Matrix Composites 4	2107 Structural Analysis and Optimization 4	2108 Multiscale Modelling of Structures 4	2109 Bio-Composites 4	2110 Thermography 1	2111 Hybrid Composites 4	2112 Office Naval Research (ONR) Session 4	2113 Joints 4	2114 Composite Structures 4	2115 Fatigue 4	2116 Stimuli Responsiveness and Shape Reconfiguration 4	2117 Design and Manufacture for Multifunctionality 4	2118 Interfaces and Interphases 4	2119 Recycling of Composites and Sustainability 3	2120 Bio and Medical 2	2121 Aerospace 4	
	10:25-10:50	Coffee Break																					
	10:50-11:25	KEYNOTE LECTURE by: 1) Woo Il Lee, Seoul National University, Korea; 2) Norman Wereley, University of Maryland, USA; 3) Ozden Ochoa, Texas A&M University, USA																					
	11:35-12:35	2201 Polymer Matrix Materials 5	2202 Metal Matrix Composites 5	2203 Fiber-reinforced Composites 5	2204 Fracture and Damage 5	2205 Nano-Composites 5	2206 Fiber-reinforced Composites 16	2207 Structural Analysis and Optimization 5	2208 Multiscale Modelling of Structures 5	2209 Bio-Composites 5	2210 Thermography 2	2211 Hybrid Composites 5	2212 Sandwich Structures and Materials 1	2213 Joints 5	2214 Composite Structures 5	2215 Fatigue 5	2216 Self-Healing and Bio-inspired Designs 1	2217 Design and Manufacture for Multifunctionality 5	2218 Interfaces and Interphases 5	2219 Recycling of Composites and Sustainability 4	2220 Bio and Medical 3	2221 Aerospace 5	
Tuesday 22 August	12:35-13:35	Lunch																					
	13:35-14:25	PLENARY LECTURE by: Tsu-Wei Chou, University of Delaware, USA - FROM STRUCTURAL TO FUNCTIONAL COMPOSITES: A PERSONAL JOURNEY																					
	14:40-15:15	KEYNOTE LECTURE by: 1) Leif Asp, Chalmers University of Technology, Sweden; 2) Andy Long, The University of Nottingham, UK; 3) Alan KT Lau, Swinburne University of Technology, Australia																					
	15:15-15:40	Coffee Break																					
	15:40-17:00	2301 Polymer Matrix Materials 6	2302 Metal Matrix Composites 6	2303 Fiber-reinforced Composites 6	2304 Fracture and Damage 6	2305 Nano-Composites 6	2306 Fiber-reinforced Composites 17	2307 Structural Analysis and Optimization 6	2308 Multiscale Modelling of Structures 6	2309 Bio-Composites 6	2310 Energy Harvesting and Storage 1	2311 Hybrid Composites 6	2312 Sandwich Structures and Materials 2	2313 Joints 6	2314 Composite Structures 6	2315 Fatigue 6	2316 Self-Healing and Bio-inspired Designs 2	2317 Design and Manufacture for Multifunctionality 6	2318 Interfaces and Interphases 6	2319 Renewable Energy 1	2320 Bio and Medical 4	2321 Automotive and Rail 1	Panel Session on Composite Regulation
	17:00-18:20	2401 Polymer Matrix Materials 7	2402 Metal Matrix Composites 7	2403 Fiber-reinforced Composites 7	2404 Fracture and Damage 7	2405 Nano-Composites 7	2406 Fiber-reinforced Composites 18	2407 Structural Analysis and Optimization 7	2408 Multiscale Modelling of Structures 7	2409 Bio-Composites 7	2410 Energy Harvesting and Storage 2	2411 Hybrid Composites 7	2412 Sandwich Structures and Materials 3	2413 Joints 7	2414 Composite Structures 7	2415 Fatigue 7	2416 Self-Healing and Bio-inspired Designs 3	2417 Tribology and Wear 1	2418 Processing-Preforming Technologies 1	2419 Renewable Energy 2	2420 Bio and Medical 5	2421 Automotive and Rail 2	
	18:30-20:00	Dinner																					

Wednesday 23 August	8:00-8:50	PLENARY LECTURE by: Huiming Cheng, Institute of Metal Research, Chinese Academy of Sciences, China - Fabrication of Graphene Materials and Their Composite Applications																					
	9:05-11:45	Mini Oral Session																					Tsai Award 1
	11:45-12:35	Poster Exhibition and Reception																					
	12:35-13:35	Lunch and Poster Exhibition																					
	13:35-14:25	PLENARY LECTURE by: Michael Wisnom, University of Bristol, UK - Creating Composites that Fail More Gradually																					
	14:40-15:15	KEYNOTE LECTURE by: 1) Jian Lu, City University of Hong Kong, China; 2) Byung Sun Kim, Korea Institutes of Material Science, Korea; 3) Brian G. Falzon Queen's University Belfast, UK																					
	15:15-15:35	Coffee Break																					
	15:35-16:55	3101 Polymer Matrix Materials 8	3102 Metal Matrix Composites 8	3103 Fiber-reinforced Composites 8	3104 Fracture and Damage 8	3105 Nano-Composites 8	3106 Fiber-reinforced Composites 10	3107 Structural Analysis and Optimization 8	3108 Ductile and Pseudo-ductile Composites 1	3109 Textile-Based Composites 1	3110 Energy Harvesting and Storage 3	3111 Dynamic Behavior 1	3112 Sandwich Structures and Materials 4	3113 Joints 8	3114 Composite Structures 8	3115 Structural Design Criteria, Safety and Reliability	3116 Self-Healing and Bio-inspired Designs 4	3117 Tribology and Wear 2	3118 Processing-Preforming Technologies 2	3119 Additive Manufacturing 1	3120 Bio and Medical 6	3121 Aerospace 6	3122 Acoustic Meta-Composite 1
	17:00-18:20	General Assembly																					
	18:30-20:00	Dinner																					

Thursday 24 August	8:00-8:50	PLENARY LECTURE by: Ray Baughman, University of Texas at Dallas, USA - STRONG, FAST, POWERFUL, DURABLE, AND CHEAP POLYMER FIBER AND HYBRID NANOFIBER YARN ARTIFICIAL MUSCLES AND THEIR APPLICATIONS																					
	9:05-10:25	4101 Polymer Matrix Materials 9	4102 Metal Matrix Composites 9	4103 Fiber-reinforced Composites 9	4104 Fracture and Damage 9	4105 Nano-Composites 9	Forum on Lightweight Structures and Composites	4107 Structural Analysis and Optimization 9	4108 Ductile and Pseudo-ductile Composites 2	4109 Textile-Based Composites 2	4110 Energy Harvesting and Storage 4	4111 Dynamic Behavior 2	4112 Sandwich Structures and Materials 5	4113 Joints 9	4114 Actuation and Dynamic Response	4115 Processing-Manufacturing Technologies 1	4116 Self-Healing and Bio-inspired Designs 5	4117 Acoustic Meta-Composite 2	4118 Process Induced Effects 1	4119 Additive Manufacturing 2	4120 Bio and Medical 7	4121 Automotive and Rail 3	
	10:25-10:50	Coffee Break																					
	10:50-11:25	KEYNOTE LECTURE by: 1)Anthony M. Waas, University of Washington, USA; 2) Jang Kyo Kim, The Hong Kong University of Science and Technology, China; 3) Véronique Michaud, Ecole Polytechnique Fédérale de Lausanne, Switzerland																					
	11:35-12:35	4201 Polymer Matrix Materials 10	4202 Metal Matrix Composites 10	4203 Fiber-reinforced Composites 10	4204 Fracture and Damage 10	4205 Nano-Composites 10	Forum on Lightweight Structures and Composites	4207 Structural Analysis and Optimization 10	4208 Ductile and Pseudo-ductile Composites 3	4209 Textile-Based Composites 3	4210	4211 Dynamic Behavior 3	4212 Sandwich Structures and Materials 6	4213 X-Ray Computed Tomography 1	4214 Constitutive Models 1	4215 Processing-Manufacturing Technologies 2	4216 Civil Engineering	4217 Acoustic Meta-Composite 3	4218 Process Induced Effects 2	4219 Additive Manufacturing 3	4220 Fibers 1	4221 Automotive and Rail 4	
	12:35-13:35	Lunch																					
	13:35-14:25	PLENARY LECTURE by: Zhongmin Xue, Sinoma Science & Technology Co., Ltd, China - Composite Material Applications to Industries in China																					
	14:40-15:15	KEYNOTE LECTURE by: 1) Christopher S. Lynch, University of California, Los Angeles, USA; 2) Chiara Bisagni, Delft University of Technology, Netherlands; 3) Milo Shaffer, Imperial College London, UK																					
	15:15-15:40	Coffee Break																					
	15:40-17:00	4301 Polymer Matrix Materials 11	4302 Metal Matrix Composites 11	4303 Fiber-reinforced Composites 11	4304 Fracture and Damage 11	4305 Nano-Composites 11	Forum on Lightweight Structures and Composites	4307 Green Composites 1	4308 Ductile and Pseudo-ductile Composites 4	4309 Textile-Based Composites 4	4310 Process Modelling 1	4311 Dynamic Behavior 4	4312 Sandwich Structures and Materials 7	4313 X-Ray Computed Tomography 2	4314 Constitutive Models 2	4315 Processing-Manufacturing Technologies 3	4316 Sensing and Self-Diagnosis 1	4317 Acoustic Meta-Composite 4	4318 Process Induced Effects 3	4319 Additive Manufacturing 4	4320 Fibers 2	4321 Smart Structures 1	
	17:00-18:20	4401 Polymer Matrix Materials 12	4402 Metal Matrix Composites 12	4403 Fiber-reinforced Composites 12	4404 Fracture and Damage 12	4405 Damage Tolerance of Composites Structures 1	Forum on Lightweight Structures and Composites	4407 Green Composites 2	4408 Ductile and Pseudo-ductile Composites 5	4409 Textile-Based Composites 5	4410 Process Modelling 2	4411 Dynamic Behavior 5	4412 Sandwich Structures and Materials 8	4413 X-Ray Computed Tomography 3	4414 Constitutive Models 3	4415 Processing-Manufacturing Technologies 4	4416 Sensing and Self-Diagnosis 2	4417 Acoustic Meta-Composite 5	4418 Process Induced Effects 4	4419 Micro- and Nano- Scale Test Methods	4420 Fibers 3	4421 Smart Structures 2	
	19:00-21:30	Banquet																					

Friday 25 August	8:00-8:50	PLENARY LECTURE by: Daniel J. Inman, University of Michigan, USA - The Role of Composites in Avian Inspired Morphing Aircraft																				
	9:05-10:25	5101 Polymer Matrix Materials 13	5102 Metal Matrix Composites 13	5103 Fiber-reinforced Composites 13	5104 Dynamic Fracture 1	5105 Damage Tolerance of Composites Structures 2	5106 Fiber-reinforced Composites 20	5107 Green Composites 3	5108 Other New Testing Methods 1	5109 Textile-Based Composites 6	5110 Process Modelling 3	5111 Composite Repair 1	5112 Sandwich Structures and Materials 9	5113 Ultrasound, Acoustic Emission, and Electromagnetic	5114 Constitutive Models 4	5115 Processing-Manufacturing Technologies 5	5116 Sensing and Self-Diagnosis 3	5117 Manufacturing Up-Scaling and Automation 1	5118 Process Induced Effects 5	5119 Experimental Methods for Process Characterization 1	5120 Fibers 4	5121 Machining of Composites 1
	10:25-10:50	Coffee Break																				
	10:50-11:25	KEYNOTE LECTURE by: 1) Zhishen Wu, Southeast University, China; 2) Yoshihiro Narita, Hokkaido University, Japan; 3) Zhengming Huang, Tongji University, China																				
	11:35-12:35	5201 Liquid Composites Moulding 1	5202 Metal Matrix Composites 14	5203 Fiber-reinforced Composites 14	5204 Dynamic Fracture 2	5205 Damage Tolerance of Composites Structures 3	5206 Fiber-reinforced Composites 21	5207 Green Composites 4	5208 Other New Testing Methods 2	5209 Textile-Based Composites 7	5210 Process Modelling 4	5211 Composite Repair 2	5212 Sandwich Structures and Materials 10	5213 Ultrasound, Acoustic Emission, and Electromagnetic waves 2	5214 Constitutive Models 5	5215 Processing-Manufacturing Technologies 6	5216 Sensing and Self-Diagnosis 4	5217 Manufacturing Up-Scaling and Automation2	5218 Offshore and Subsea 1	5219 Experimental Methods for Process Characterization 2	5220 Fibers 5	5221 Machining of Composites 2
	12:35-13:35	Lunch																				
	13:35-14:25	PLENARY LECTURE by: HeeJune Kim, LG Hausys R&D Center, Korea - Technologies Overview for Composite Materials and Automotive Components in Korean Automotive Industry																				
	14:25-14:50	Coffee Break																				
	14:50-17:10	5301 Liquid Composites Moulding 2	5302 Metal Matrix Composites 15	5303 Fiber-reinforced Composites 15	5304 Dynamic Fracture 3	5305 Damage Tolerance of Composites Structures 4	5306	5307 Green Composites 5	5308 Other New Testing Methods 3	5309 Textile-Based Composites 8	5310 Process Modelling 5	5311 Composite Repair 3	5312 Sandwich Structures and Materials 11	5313 Ultrasound, Acoustic Emission, and Electromagnetic	5314	5315 Processing-Manufacturing Technologies 7	5316 Sensing and Self-Diagnosis 5	5317	5318 Offshore and Subsea 2	5319 Experimental Methods for Process Characterization 3	5320 Fibers 6	5321 Machining of Composites 3
	18:00-20:00	Dinner																				

附件二、 發表報告全文

MARBLE BASED GREEN CEMENT BY USING GEOPOLYMER TECHNOLOGY

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Keywords: Marble, Blast furnace slag, Geopolymer, Green Cement.

ABSTRACT

Greenhouse effect is an important topic since it has been responsible for global warming. Carbon dioxide also plays a part of role in the greenhouse effect. Therefore, human has the responsibility of reducing CO_2 emissions in their daily operations. Except iron making and power plants, another major CO_2 production industry is the cement industry. Estimation by EPA of Taiwan, production 1 ton of cement will produce 520.29 kg carbon dioxide. There are 7.8 million tons of CO_2 produced annually. Thus, to synthesize low CO_2 emission geopolymeric green cement is important and can reduce CO_2 emission problems in Taiwan.

The purpose of this study is trying to use marble wastes as the raw material to fabricate geopolymer green cement. Experiment results show that the setting time of green cement was exceed 4 hours. After curing 28 days, the compressive strength of marble based geopolymer green cement paste can reach 65 MPa, that is higher than traditional Portland Cement.This study is based on resource recovery and recycling. Its basic characteristics are low consumption, low emission and high efficiency that meet the Taiwan government's policy of "Circular Economy", and this is an international tendency. According to experimental results, the marble-based geopolymer green cement can be developed as a low CO_2 emission green cement. By comparing with Portland cement paste, production 1 ton of marble-based geopolymer green cement paste, it can be saved around 53.8% carbon dioxide emission. Production 1 ton of green cement paste will cost about 1350 NTD (~42 USD) that cheaper than traditional Portland cement paste. It is proved that the green cement has very good potential for further engineering development in the future.

1 INTRODUCTION

The greenhouse effect is an important topic since it has been responsible for global warming. Carbon dioxide also plays a part of role in the greenhouse effect. Therefore, human has the responsibility of reducing CO_2 emissions in their daily operations. According to International Energy Agency IEA/OECD statistics in 2015, energy related carbon dioxide emissions was over 248.7 million tonnes in Taiwan and ranked No. 22 in the world's [1]. It is well known that the production of OPC emits large quantity of carbon dioxide [2]. Cement manufacturing is one of the highest carbon dioxide emission industries. According to EPA of Taiwan statistics in 2015, production 1 tons of cement will produce 520.29kg CO_2(not including mining development stage). There are 15 million tonnes of cement will produced every year in Taiwan, it means 7.8 million tonnes of CO_2 produced annually in Taiwan by cement industries. Thus, to synthesize low CO_2 emission geopolymeric green cement is important and can reduce CO_2 emission problems in Taiwan.[3]

Geopolymer, similar to natural zeolite minerals, is a class of three-dimensionally networked alumino-silicate materials [2], and is an inorganic non-metallic material newly developed in recent years. Due to its superior mechanical and physical properties, such as non-combustible, heat-resistant, fire/acid resistant, easy to make it, and formed at low temperatures, geopolymer have been gradually attracting world attention as potentially revolutionary green materials. Previous studies have presented when using geopolymeric technology to make geopolymer could reduce over 70 % carbon dioxide emission [5].

In this study, marble and blast furnace slag (BFS) were used as raw materials to fabricate marble-based geopolymeric green cement under the activation of alkaline solutions of various molar ratios at ambient condition. The characteristics of marble-based geopolymeric green cement in workability (viscosity, setting time), compressive strength, specimen shrinkage and ^{29}Si, ^{27}Al NMR analysis were presented in this study.

2 EXPERIMENTAL

The marble samples used in this study were collected from a marble mine in eastern Taiwan. The blast furnace slag (BFS) samples were produced from China Steel in southern Taiwan. The chemical composition of marble and BFS were analyzed by X-ray fluorescence (XRF), as listed in Table 1.The major composition in marble and blast furnace slag was calcium oxide, however, the blast furnace slag also contains 27.7 % of SiO_2. Alkali solution was prepared by mixing NaOH, sodium silicate and sodium aluminate, the SiO_2/Na_2O molar ratio was controlled at 1.28 and 1.5, the SiO_2/Al_2O_3 molar ratio was controlled at 20, 50 and 100 . The experimental procedure and test parameters were shown in Figure 1 and Table 2.

The setting time test of green cement was followed CNS 786 and analysis by Vicat Needle. Compressive strength test of green cement was followed CNS 1232. Specimen shrinkage test was followed CNS 1258. According to CNS 3036, the specimen shrinkage should less than 0.8%.

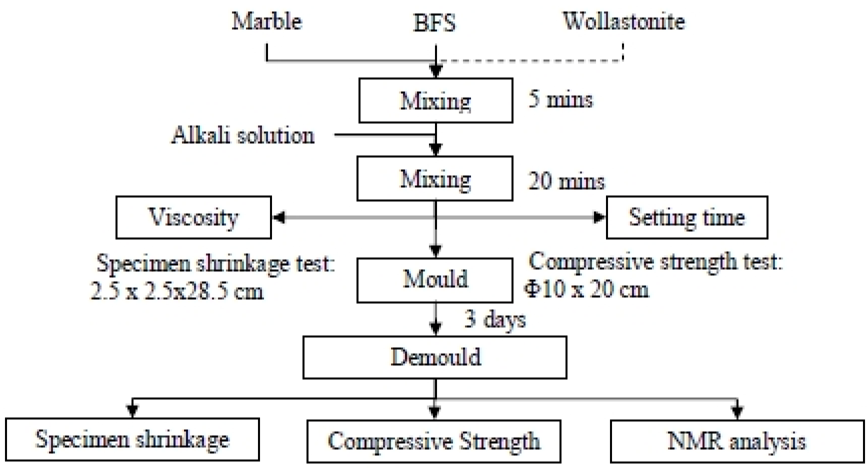


Figure 1: Overall experiment procedures

Composition / wt. %	SiO_2	CaO	Al_2O_3	Fe_2O_3	L.O.I.	Other
Marble	1.0	60.9	1.3	-	35.6	1.2
Blast furnace slag	27.7	57.9	11.2	0.4	-	2.8

Table 1: Marble & Blast furnace slag Chemical Composition

Experiment No.	Solid Materials wt.%	Alkali Solution			Liquid / Solid wt.% ratio
	Marble: BFS	NaOH	SiO_2/Na_2O	SiO_2/Al_2O_3	
MS01	80:20	6M	1.28	20	0.55
MS02			1.5	50	
MS03			1.28	100	
MS04			1.5	20	
MS05			1.28	50	
MS06			1.5	100	
MS07	60:40	6M	1.28	20	
MS08			1.5	50	
MS09			1.28	100	
MS10			1.5	20	
MS11			1.28	50	
MS12			1.5	100	

Table 2: Experiment Parameters

3 RESULTS AND DISCUSSION

3.1 Workability of green cement (viscosity, setting time)

The effects of different parameters on workability of green cement are shown on Table 3. The viscosity of green cement paste can be decreased by increases the amount of sodium aluminate in alkali solution. The initial and final setting time increases as the amount of sodium aluminate in alkali solution increases. Because green cement was formed by geopolymerization, and the structure of geopolymerization usually was Si-O-Al, it means more Al involved in reaction, the structure of green cement will more complete. As the results shown, when geopolymerization more complete, more geopolymer gel will release, thus the viscosity of green cement paste will decrease and the setting time of green cement will increased.

However, when increased the amount of sodium aluminate in alkali solution will making alkali solution unstable, thus the SiO_2/Al_2O_3 =20 was the limitation of the adding amount of sodium aluminate.

According to the experiment results and the properties of portland cement, while using different parameters to form green cement, the viscosity of paste can be less than 5000 mPa・s, the initial setting can longer than 45 min, and the finial setting time can less than 360 min.

3.2 Compressive strength test

The effects of different parameters on compressive strength of green cement are shown on Figure 2 and Figure 3. As the results shown, the compressive strength of green cement was affected by the mixing ratio of marble and BFS. The compressive strength of green cement increases as the amount of BFS increase. Because BFS has higher reactivity than marble, and it leads the geopolymerization more complete.

However, micro cracks on geopolymer specimen were observed if the amount of BFS is over 40 %, and thus, the amount of BFS can't be increased over than 40%. According to the experiment results, the compressive strength of green cement can be reached over 40MPa. Compare with portland cement, the compressive strength of green cement was higher than Portland cement.

Experiment No.	Solid Materials wt.%	Alkali Solution			Viscosity (mPa·s)	Setting time (min)	
	Marble: BFS	NaOH	SiO_2/Na_2O	SiO_2/Al_2O_3		Initial	Final
MS01	80:20	6M	1.28	20	4100	125	225
MS02			1.5	50	3900	95	170
MS03			1.28	100	8250	45	65
MS04			1.5	20	2500	135	180
MS05			1.28	50	4150	75	110
MS06			1.5	100	2400	85	140
MS07	60:40	6M	1.28	20	4100	100	145
MS08			1.5	50	5700	30	60
MS09			1.28	100	8500	35	60
MS10			1.5	20	4200	40	80
MS11			1.28	50	4150	60	85
MS12			1.5	100	8300	30	55

Table 3: Workability of green cement (viscosity and setting tim)

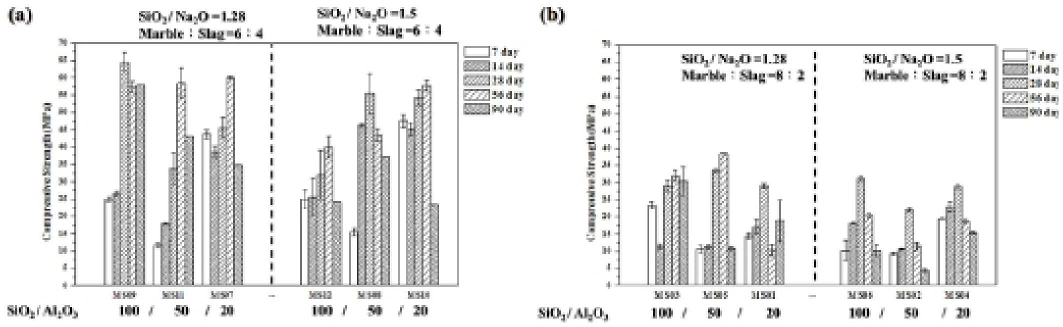


Figure 2: Effect of various alkali solution condition on green cement compressive strength (a) Marble / BFS wt.% ratio = 60:40 (b) Marble / BFS wt.% ratio = 80:20. Liquid / Solid wt.% ratio = 0.55.

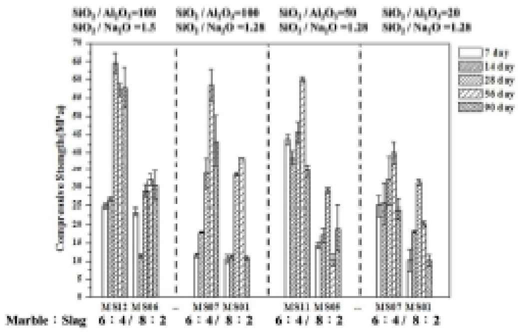


Figure 3: Effect of marble/BFS ratio on green cement compressive strength. Liquid / Solid wt.% ratio = 0.55.

3.3 Specimen shrinkage test and improvement

Due to the micro cracks was observed on marble based green cement. These micro cracks were generated from shrinkage as shown on table 4. Thus, in this part of experimental is trying to add some filler to improve the shrinkage issue. As the results shown on table 4, the shrinkage issue of green cement can be improved when adding wollastonite into green cement. Because the particle shape of wollastonite is needle-like, when green cement dehydration, it can grabs different particles to prevent shrinkage. According to experiment results, when adding 1wt% of wollastonite into green cement, the specimen shrinkage can be controlled belows to 0.8%.

Experiment No.	Specimen shrinkage (%) in different curing days			Curing method
	7 days	14 days	28 days	
MS11	-2.33	-2.4	-2.46	Curing in ambient temperature
MS11 - 1wt% Wollastonite	-0.51	-0.53	-0.63	Curing in ambient temperature
MS11- 3wt% Wollastonite	-0.23	-0.35	-0.42	Curing in ambient temperature
MS11- 5wt% Wollastonite	-0.04	-0.21	-0.25	Curing in ambient temperature

Table 4: Shrinkage of green cement - Results of before and after improvement

3.4 NMR analysis

After 28 days curing, marble-based green cement sample was analyzed using Nuclear Magnetic Resonance Spectroscopy (NMR).

NMR analyze results as shown in Figure 4, it can be found that the Q_4^4 in marble based green cement, the Q_4^4 area was increased when increased the amount of slag. This is because slag have better reaction, after geopolymeric reaction, slag can dissolve large amount of Si for forming Q_4^4. In marble-based green cement system, the main Si sources is BFS or sodium silicate, therefore over 50% Q_4^4 was measured in the marble based green cement. According to the analyze results, the ^{27}Al structure in green cement was major with Al(IV), it means most Al were bond with Al-O-Si.

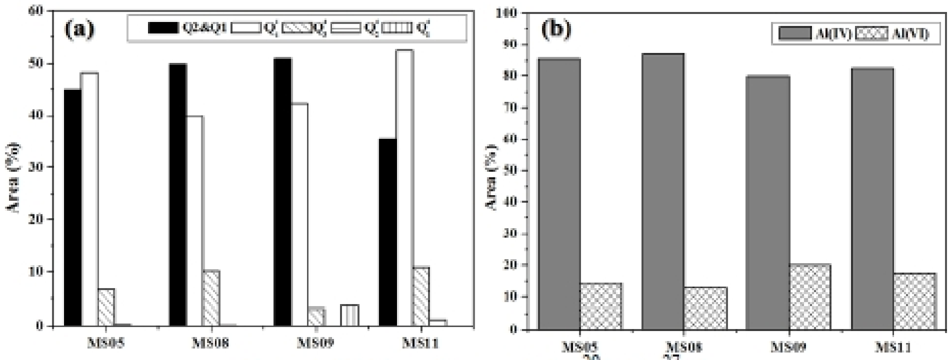


Figure 4: NMR analyze result (a) ^{29}Si (b) ^{27}Al

3.5 Green cement- CO_2 emission estimate

According to Taiwan EPA statistics in 2015, production 1 tons of portland cement will produce 520.29kg CO_2 (not including mining development stage). The statistics of CO_2 emission on marble based green cement as shown on table 5. By comparing with Portland cement paste, production 1 ton of marble based green cement paste, it can be saved around 53.8% carbon dioxide emission.

Item	Marble based green cement paste	Portland cement	Portland cement paste
CO_2 emission estimate	0.17162 ton CO_2 /ton green cement	0.52029 tonCO_2 /ton cement	0.37200 ton CO_2 /ton cement paste
CO_2 emission reduction	-	67.0%	53.8%

Table 5: CO_2 emission estimate of green cement paste (compare with Portland cement paste)

4 CONCLUSIONS

Marble and BFS based green cement was successfully developed in this study. After curing for 28 days, the compressive strength of marble-based green cement can reachs 42~60 MPa. The viscosity of geopolyme paste can be controlled between 2400 ~ 8250 mPa • s, and the final setting time can be controlled between 55~220 min. After adding needle-like filler into green cement system, the shrinkage issues can be improved. It is believed that the fabrication of marble-based green cement has great potential for engineering application.

REFERENCES

[1] IEA/OECD Key World Energy Statistics, 2015 Edition

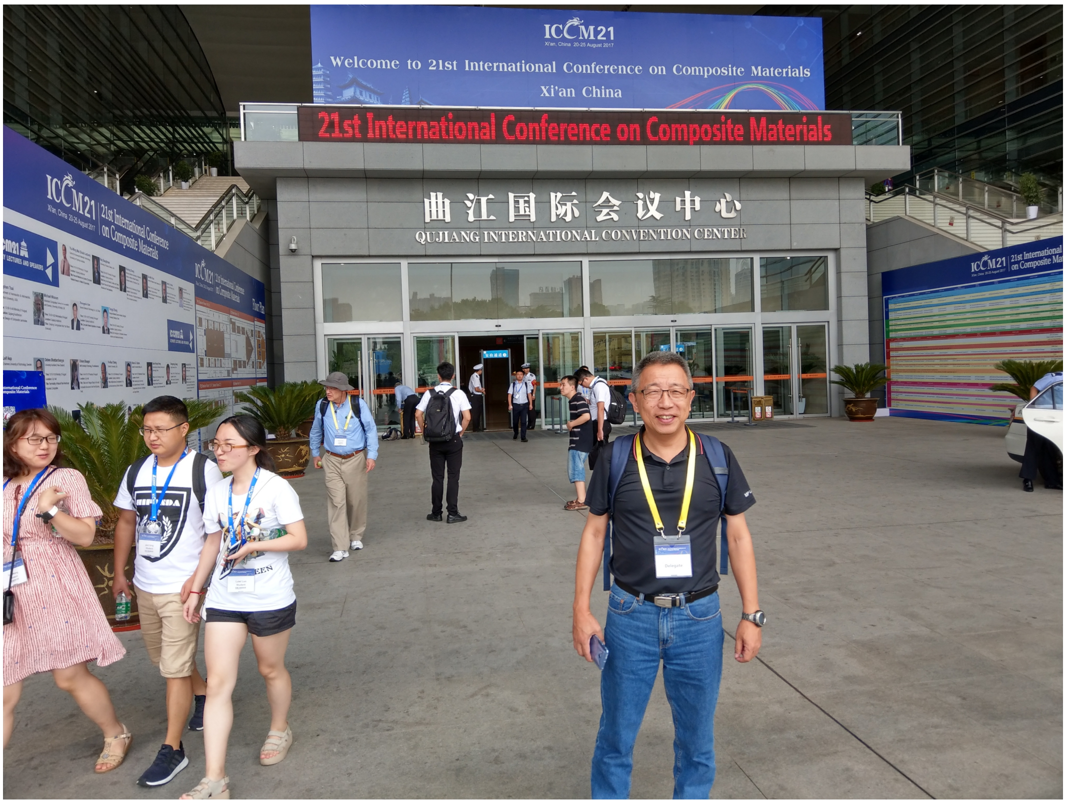
[2] D. L.Y. Kong, J. G. Sanjayan, *Damage behavior of geopolymer composites exposed to elevated temperatures*, Cement & Concrete Composites, 30, 2008, pp. 986-991.

[3] Taiwan Environmental Protection Administration, Taiwan Greenhouse Gas Inventory Executive Summary, 2015 Edition

[4] I. Lecomte, C. Henrist, M. Li´egeois, F. Maseri, A. Rulmont, R. Cloots, *(Micro)-structural comparison between geopolymers, alkali-activated slag cement and Portland cement*, Journal of the European Ceramic Society, 26, 2006, pp. 3789-3797.

[5] Davidovits J., 2015, False Values on CO_2 Emission for Geopolymer Cement/Concrete published In Scientific Papers, Technical Paper #24, Geopolymer Institute Library, www.geopolymer.org.

附件三、 相關照片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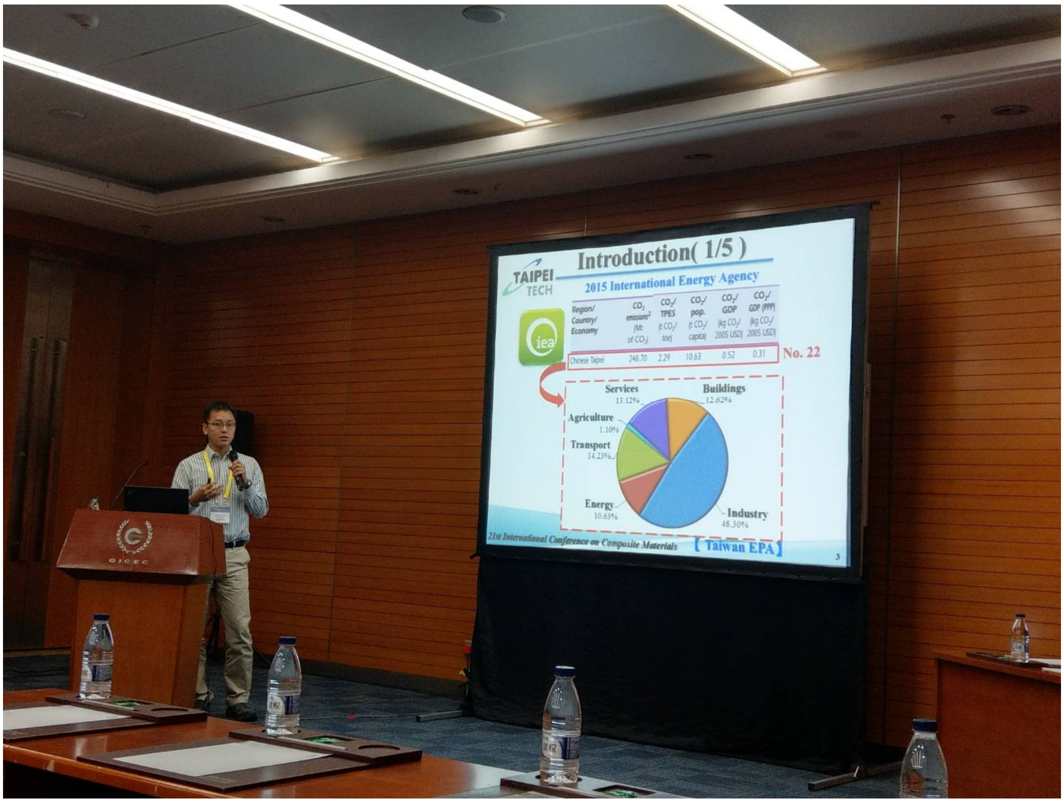
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附件四、 出國報告審核表

附件二

出國報告審核表

出國報告名稱：

出國人姓名（2人以上，以1人為代表）	職稱	服務單位
鄭大偉	教授	國立台北科技大學

出國類別：☐考察 ☐進修 ☐研究 ☐實習 ☑其他 國際研討會（例如國際會議、國際比賽、業務接洽等）

出國期間：106年8月21日至106年8月25日　報告繳交日期：106年09月22日

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☑	☑	4.內容充實完備
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鄭大偉		礦業輔導組 技正兼組長 賴欽	礦務局 局長 徐景文

說明：

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