LIVERPOOL JOHN MOORES UNIVERSITY

Faculty Research Day

Wednesday

29th June 2022

Conference Papers

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The Industry 4.0 Mapping Technique for Strategic Seaport Management

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Abstract. Seaports are regarded as vital nodes within maritime supply chains and underpin the continued commercial success of globalisation and free-market economies. In 2017, 10.7 billion tons of throughput were handled by seaports which represent 80% of all trade by volume when compared to other modes of transportation. However, seaports are conservative in nature, lagging behind the financial, automotive, and manufacturing sectors in the implementation and application of Industry 4.0 embedded technologies. Seaport operations are also underpinned by fragmentation, complexity, and market uncertainty. This unique operating environment is an ideal candidate for the sustained competitive advantages offered by the Industry 4.0 paradigm. A range of data mapping tools have been adapted from Value Stream Mapping (VSM) as a method to facilitate seaport management with an improved understanding of their current state and ideal future state with regards to Industry 4.0 technologies.

Keywords. Industry 4.0, Value Stream Mapping (VSM), Supply Chain Management,

1. Introduction

Seaports are complex, dynamic, networks, and nodes that consist of diverse actors and stakeholders with their own contrasting opinions, interests, operating procedures, and concerns (Botti et al., 2017). Seaport operations are also underpinned by a high degree of fragmentation that limits cooperation between actors and the sharing of knowledge (Irannezhad, Prato, and Hickman, 2020). There is a general consensus in the literature that seaports represent an exciting opportunity for empirical and theoretical study due to their complexity, governance, size, scale, type of operation, culture, and current understanding of Industry 4.0 capabilities (Lee et al., 2018).

2. Value Stream Mapping (VSM)

The application of VSM techniques within seaports and container terminals was first advocated by and Paixão – Casaca (2003) who acknowledged its capability to identify waste in the supply chain. Loyd et al., (2009) employed VSM techniques to measure and improve throughput volume at the McDuffie Coal Terminal within the Port of Mobile (Alabama, USA). A similar approach was conducted by Franzén and Streling (2017) who conducted four case studies at seaport container terminals to identify eventual inefficiencies through traditional VSM techniques. They concluded that seaport operations in the short-term need enhanced situational awareness of their operational assets, while a long-term strategy should leverage the implementation of automated container handling and technology to systematically reduce human error and promote procedural standardization (Franzén and Streling, 2017). Meudt, Metternich, and Abele (2017) integrated VSM and Industry into a Value Stream Mapping 4.0 model that aimed to identify the location of information logistics waste (ILW) within the SC operation. Huang et al., (2019) developed Cyber-Physical Systems to function as a multi-agent system that may populate an innovative multi-layer dynamic value stream mapping (DVSM), identifying multi-material and information flows. A multi-agent system is a cluster of autonomous agents representing physical or logistical units connected by a network that possesses the capacity to sense and regulate autonomously in a complex and dynamic operating environment.

The increasing pressure on seaports to deliver increased throughput capacity that is subjected to infrastructure and economic constraints is a very complex issue (Loyd et al., 2009; Olesen et al., 2015). The process of VSM mapping in relation to the implementation of smart technology is a viable solution to this issue. This approach is advocated by Olesen et al., (2015) who suggest that further research

should examine the combination of innovative IT platforms with lean management concepts, contributing to the body of knowledge.

3. Industry 4.0 – The Fourth Industrial Revolution

The seaport and maritime sectors are substantially lagging behind in the implementation and application of Industry 4.0 embedded technologies. It is argued by de la Pēna Zarzuelo, Soeane, and Bermúdez (2020) that the level of implementation is sporadic and not confined to any geographical region. There is a significant lack of empirical studies that document the multi-dimensional innovation of Industry 4.0 technologies (technological, managerial, organisational, and cultural concepts) within the seaport complex, despite the realisation that advanced ICT now represents a critical success factor in determining seaport competitiveness

4. Methodological Approach

A systematic literature review was primarily conducted to determine the current state of VSM adaptation in relation to the application of Industry 4.0. The mapping process will be underpinned by an Action Research methodology that involves semi-structured interviews, direct process observation, practitioner participation, direct measurement, and process flow mapping.

The global COVID 19 pandemic and subsequent national lockdowns in the United Kingdom necessitated a systematic redesign of the research scope in terms of participant identification, selection, and engagement. Therefore, a global research sample was selected via a call for participants email that outlined the rationale behind the research project, motivation, aims, objectives, and ethical constraints.

A systematic search of seaport databases (Searates) facilitated the identification of potential participants to be approached. This process included both seaports and container terminals, as well as international associations and NGAs (British Port Association, International Port Community Association, and Intercargo) who provided additional context on the motivation and drivers of seaports to upgrade their existing infrastructure to be Industry 4.0 ready. It was deemed that all seaport operations are not mutually exclusive in their functionality, and they are generators of vast amounts of structured and unstructured data in their own right. Some additional clarification was necessary as seaport operators questioned if this research opportunity was only targeted toward containerised operations. A series of three semi-structured interviews with 10 global maritime logistics operators. The Seaport Authority of Virginia and the North-West Seaport Alliance (Seaports of Tacoma and Seattle) expressed an interest in this research project and they were subsequently invited to participate in a more in-depth semi-structured interview and a presentation that demonstrated the mapping procedure. The flexible nature of the semi-structured interviews method allowed for a detailed overview of the drivers of Industry 4.0 embedded technological adaptation. The application of semi-structured interviews enables the interviewer to develop great insight into the subject matter, permitting a more reasoned understanding of the views expressed by the participants. Prior to the application of the semi-structured interviews, full acceptance was obtained from the LJMU Research Ethics Committee (Registration Number 21/MME/001). Due to page constraints, this paper will only focus on the operations at the Seaport Authority of Virginia and the utilisation of the Process Flow Mapping tool.

4.1. The Seaport Authority of Virginia

Virginia is a mid-Atlantic seaport that is located 2.5 hours away from the open sea, providing direct trade routes with Europe. The seaport has an extensive infrastructure that consists of six terminals that are able to process over 4 million containers annually. The seaport is a public entity that has received significant state funding to increase container capacity and stimulate the economy in terms of employment and infrastructure redevelopment.

5. The Industry 4.0 Mapping Technique

This mapping tool is a response to market demands ascertained during the literature review and the semi-structured interviews. Industry 4.0 will be integrated into VSM as a real data collection tool to

facilitate insight between the physical throughput of cargo and the generation of KPIs, utilised in determining the performance of the operation. A digitalised map of the seaport will be divided into squares to establish the accurate location of the sensors and it will also record the flow of both open and closed information utilised in the generation of KPI measurements. The flow of information may also be recorded in a graphical format. The mapping of the flow of information within the seaport's value chain will enable the determination of the optimal location of the interoperable Industry 4.0 sensors to generate quality data sets, providing enhanced data confidence. This will enable a continuous monitoring system to display the performance consistency of the seaport.

5.1. Process Flow Mapping Current State

Process Flow Mapping constitutes the following steps. Firstly, a preliminary analysis of the operation to be mapped is undertaken with the execution of a process walk-through. This is subsequently followed by a detailed data capture of all activities in the integrated fulfilment of each process. This will include the location or area of deployment for each semi or fully automated machine, distance transited, time taken, duration of operation, downtime, information flow and interoperability, data structure, static and remote decision points, level of human intervention/ interaction, and data dissemination storage The collated data will be populated into a walk-through flow chart. A current state Process Activity Map provides an excellent opportunity for the identification of aspects which require improvement, under the traditional Lean Methodology of continuous improvement and it also signifies a strategy to bridge the perceived gap in the maritime sector's Industry 4.0 competence.

The current state of container loading was mapped out at the Virginia Seaport Authority

1. Contract of Carriage signed between the shipper and line operator.
2. Vessel sharing agreement between the line operator and the ship operator.
3. Third-Party Logistics provider may be involved to arrange for the goods to be stuffed into a container and transportation to the seaport/ container terminal.
4. Issuing of customs clearance and preliminary import customs at the destination country.
5. Transportation of container from the shipping point of origin to the outbound container yard.
6. On-terminal straddle carrier operation reception, validate, store, plan, and load the appropriate container ship. It was also suggested that the Process Flow Map should intermix loading and unloading operations of the gantry crane. This function is known as cycling and systematically reduces the empty movements of the gantry crane, enhancing operational productivity and reducing ship turnaround times by approximately 50%. This also enhances berth utilisation and reduces bottlenecks of ships attempting to enter the seaport.
7. Ship transit.
8. Offloading from the ship including the functions of planning, discharge, and movement to storage location in the container yard.
9. Destination customs final clearance.
10. Intermodal transportation to Beneficial Cargo Operator (BCO)/ owner. This stage typically has another layer of systems integration (planning and services) related to moving the container to the 'last mile' in the supply chain.

5.2. Process Flow Mapping Ideal Future State

The theoretical mapping of the Process Flow Ideal Future State was based on the market demands for increased levels of supply chain visibility and transparency, systematically increasing the value of the services offered to the shipper and end-user. This concept may cater for single or multiple container movements that constitute sensitive or high-value orders. To accelerate this capability a process of continuous monitoring by RFID tags was advocated (Figure 1). This near real-time functionality will be exploited as a sustained competitive advantage as the Seaport Authority of Virginia has recently become a member of the Tradelens platform. Tradelens disseminates end-to-end visibility of containerised freight and facilitates trade as a trade document collaboration tool for integrated stakeholders.

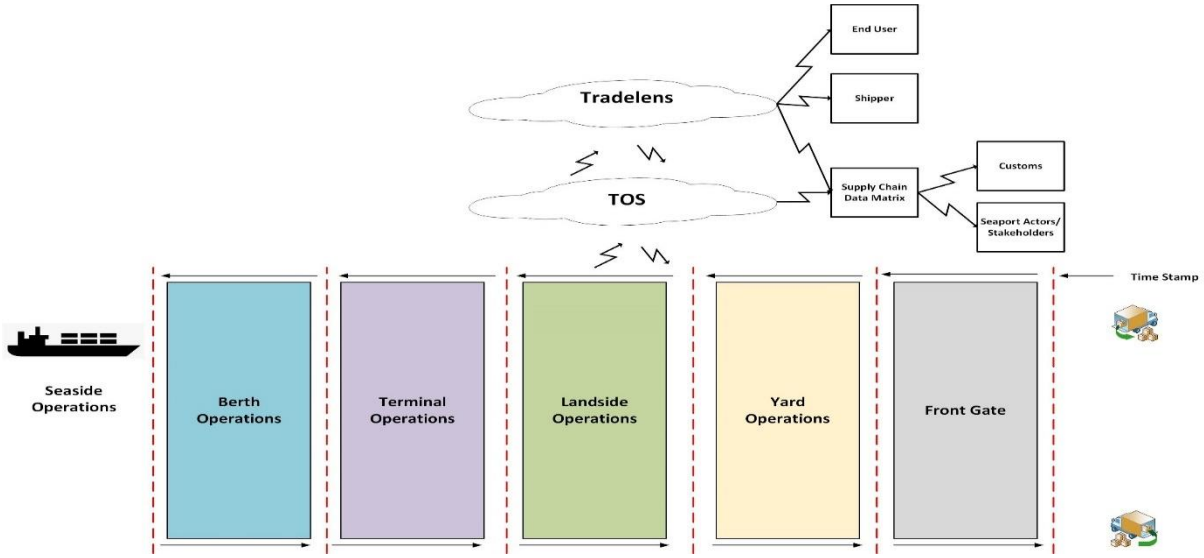

Figure 1 Process Flow Mapping – The Ideal Future State.

6. Insights and Summary

It has become apparent in the literature reviews and the semi-structured interviews that VSM tools are suitable for adaptation to map the current and future state of Industry 4.0 technological implementation and application. This will assist seaport managers in the formulation of strategic master plans that forecast longitudinal investment and innovation, subject to geographical infrastructure constraints. One of the most significant barriers to the adoption of Industry 4.0 in the seaport sector is the apparent lack of clarity in regards to understanding the current position. To fill this gap this chapter suggests a range of tools that provide qualitative answers to a seaport's current position and future strategy that is underpinned by a clear implementation plan.

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“Quality of work” as a root cause for disputes in the Sri Lankan construction industry

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One of the major factors contributing to the project performance is the project quality which can be achieved by a quality work. Quality of the work was identified as a main root cause of disputes in the construction industry. Therefore, this study aims to explore the disputes related to quality of work through 10 semi-structured interviews from adjudicator/arbitrator. 3 owner-related, 4 contractor-related, 3 design-related, 1 project-related, 2 consultant-related and 2 human behaviour-related disputes were identified. This study recommends that active technical evaluation committee and carefully prepared contract agreement will be the major contributor in mitigating those disputes.
Keywords. Quality of work, root cause, disputes, construction industry

1.0 Introduction

The construction projects function with various parties such as owners (both government and private companies), designers, contractors, suppliers, subcontractors, and bankers (1). This can range from large multinational contractors to one-man bands (2). When trying to attain the aims of individuals with different perspectives, disagreements tend to emerge, which ultimately leads to disputes (3). Construction disputes are often technically complex, involving mixed issues of fast and lay (4). A dispute is defined as “Incompatible activities, which occurs when the behaviour of one person is interfering or obstructing the actions of another” (5). Disputes negatively affect the project performance (6) which can link to performance measurements of construction project success (7).

2.0 Link between project performance and quality of work

Project quality is one of the major factors contributing to project performance in the Sri Lankan construction industry (6, 8). However, the contractor’s initial definition of quality is “how well the project constructed conforms to design specifications” (9). On the other hand, the customer’s focus on quality is how their needs and expectations are met in the final product (10). Further it was found that product quality refers to achieving quality in the materials, equipment, and technology that go into the building of a structure, whereas process quality refers to achieving quality in the way the project is organized and managed in the three phases of design, construction and operation, and maintenance (10).

3.0 Quality of work as a cause for disputes

Considerable number of studies exists on causes of disputes in the construction industry (11). They identified the quality of work as one major cause of dispute related to the contractor, as listed in Table 1.

Table 1 Research on "Quality of work" as a disputing cause

Reference	Quality of work-related disputes
Perera et. al., (2021)	The root cause of variation - poor workmanship

Edirisinghe et.al, (2020); Cakmak and Cakmak, (2014)	Contractor related – the quality of work
Illankoon et al., (2019); Equbal and Banerjee, (2017)	Quality issues
Gunarathna et al., (2018).	Work-related conflicts
Mahamid,(2016)	Micro-level - poor quality of completed works
Divakar and Kumar, (2015)	Sources of disputes - the quality of construction
U. Farooqui et al., (2014); Thobakgale et al.,(2014)	Construction-related
Hameed Memon et al., (2014); Rhys Jones, (1994)	Poor workmanship
Halwathura and Ranasinghe (2013)	Defective workmanship
Cheung and Pang, (2013)	Defectiveness
Jaffar et al., (2011)	Technical -contractor's quality of work
Dangrochiya et al., (2006)	Lack of quality control
Chan and Suen (2005; Conlin et al. (1996)	Quality of works
Ashworth (2005)	Subcontractor's quality
Adriaanse (2005)	Material/workmanship quality
Killian (2003)	Site management - quality control
Duran and Yates, (2000)	Process problems - Poor performance in executing the work
Kumaraswamy, (1997)	Root cause - unrealistic quality targets by clients

Quality of work has been categorized under different disputing categories by those researchers listed in Table 1 such as the root cause of variation, contractor-related, work-related conflicts, micro-level, sources of disputes, construction-related, technical, sub-contractor, and process problems. This categorization demonstrated that quality of work has taken on numerous forms, including being a cause of another conflict, a person-created dispute cause, and a work/process-related dispute cause. However, in this study, the quality of work was classified as a contractor-related conflict, one of eight categories of disputes in the Sri Lankan construction industry (Edirisinghe et al., 2020).

2.0. Method

Semi-structured interviews were conducted as part of this study with the local experts in Sri Lankan construction projects, and registered arbitrators/adjudicators in the Construction Industry Development Authority, Sri Lanka. The purpose of the interviews was to strengthen and verify the research areas in the Sri Lankan context. The experts were 8 Arbitrators/Adjudicators (AA), and 12 industry practitioners, representing Consultant Engineers (CE), Consultant Quantity Surveyors (CQS), Consultant Architects (CA), and Senior Engineers (SE). All participants have 13-56 year range of experience and working in high-level positions in their construction organizations, in Sri Lanka. The selected arbitrators/adjudicators were popular in resolving disputes in all most all the local constructions and international constructions contracts. Other participants occupy senior managerial positions in large construction firms.

3.0 Data Collection and analysis

A list of dispute causes categorized under eight (8) different dispute categories was presented to the interviewees, and they were asked to identify the existence of those disputes and the relationships which potentially existed between them. The quality of work that was listed under contractor-related dispute was agreed upon by the interviewees as the contractor-generated dispute in the Sri Lankan construction industry. Further, interviewees mentioned two distinct behaviour of the ‘quality of work’ as a cause of dispute such as a dispute creator and a consequence of several other disputes. Those findings are presented in Figure 1 below.

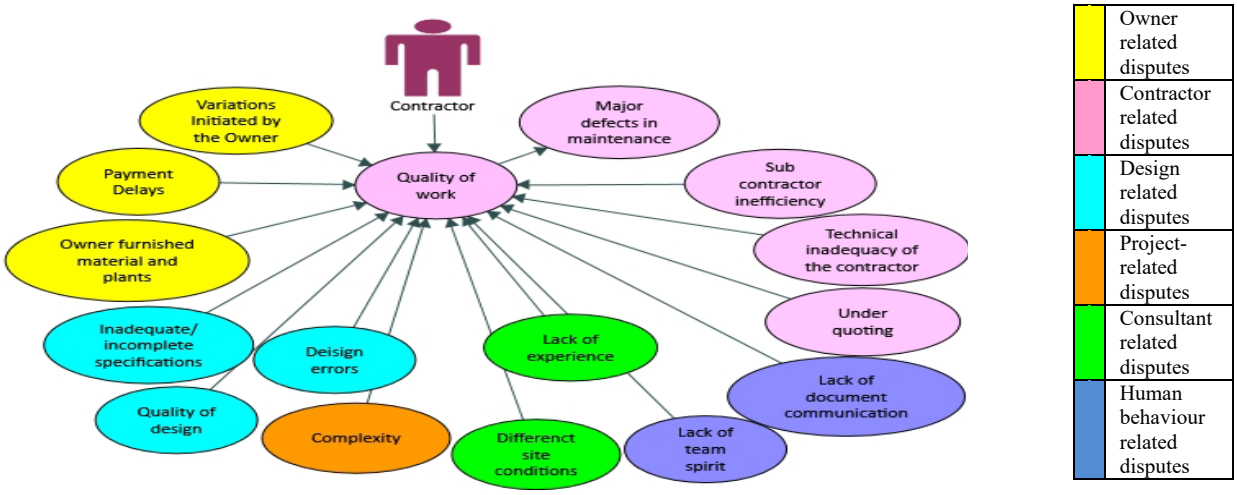

Figure 1 Relationship between quality of work and other disputes

Figure 1 shows, quality of work is the result of several other disputes related to owner-related, contractor-related, design-related, project-related, consultant-related, and human behaviour-related categories. Sub-contractor inefficiency, technical inadequacies of the contractor and under quoting is the main causes that create poor quality of work as a dispute. Ultimately, these causes will result "major defects in maintenance" due to the poor quality of work. In terms of owner-related disputes such as variations initiated by the owner, payment delays and owner-furnished materials and plant are some of the other reasons that impact on quality. When the project is of a complex nature, consultants inexperienced to handle the project, and when site conditions are challenging, quality of work issues can take place. Another set of disputes include inadequate/incomplete requirements and design quality, and design errors, all of which fall under design-related disputes and do contribute to quality of the work. Finally, the human-related lack of team spirit and lack of document communication was also found.

4.0 Conclusions and recommendation

It can be concluded that a conflict over the quality of work is the result of multiple disputes under five distinct dispute types that arise over the project's construction and maintenance phase. It also revealed that the main parties to the contract (owner, contractor, and consultant) are responsible for keeping the quality of work and preventing it from becoming a cause of dispute. However, it is interesting to find that the project itself can lead to poor quality depending on its complexity. Furthermore, a main contract document which refers to quality of work such as design and specification details, also need to be well prepared to avoid any dispute related to the work quality.

This study recommends the mitigation measures for the disputes related to quality of work as presented in table 2. The data collected from the interviews identified that all the owner-related disputes can be resolved by acting according to the form of the contract. Similarly, the design-related disputes can be resolved during the design phase through technical evaluation committee assistance by careful consideration being given to under quoting. Except for the major defects in maintenance all the other disputes can be controlled using a suitable selection process. Finally, if the quality of work is of the required standard there will not be major defects during the maintenance phase.
Table 2 Suggestions to mitigate disputes related to the quality of work

Table 2 Recommendations to mitigate disputes related to Quality of work

Category	**Quality of work-related disputes**	**Mitigatory measures**
Owner	Variations initiated by the owner, Payment delays, Owner furnished materials & plant	Refer to the clauses of the contract document

Contractor	Sub-contractor inefficiency	Select a suitable person for the work
	Technical inadequacy of the contractor, Under quoting	Technical evaluation committee
	Major defects in maintenance	Keeping the work quality
Design	Design errors, quality of design, inadequate/incomplete specifications	Technical evaluation committee
Project	Complexity	Make the project simplified by breaking it into phases
Consultant	Lack of experience	Select suitable person
	Differing site conditions	Refer to contract agreement
Human behavior	Lack of document communication, lack of team spirit	Providing proper training.

The number of disputes related to quality of work from different categories indicated that disputes are not operating alone but to several others. Therefore, when improving the dispute resolution (DR) methods the finding is useful to understand the dispute generating pattern to come up with the properly developed DR.

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Risk Assessment – smoke, mirrors, and misdirection

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Abstract:

The renewable industry like many other sectors has developed a plethora of risk assessments to fulfil its legal obligations to provide a safe and healthy workplace. Whilst risk assessments are legally mandated, analysis of their proportionality, applicability, and reliability in protecting end users from hazard realization is seldom considered. Early research indicates that published risk assessments that are in daily use, frequently contain risk reduction measures that have minimal impact on reducing risk, give guidance that may or may not be followed (choices) or simply supply additional instructions which should be contained within other safety documentation (work instructions). Additionally, Risk published risk assessments are regularly scrutinized by internal and external stakeholders who will have a view dependent on their own vested interest and risk appetite. Endeavouring to accommodate the mixed perception, opinions and beliefs of multiple stakeholder audience inevitably leads to the creation of highly bureaucratic and complex risk assessments that are difficult to understand and lack evidence to support risk reductions

Keywords: Risk, Risk Assessment, Hazard,

1. Introduction and background:

The purpose of a workplace risk assessments is broadly agreed. Risk assessments should identify what could cause injury or illness in a business (HSE 2022). However, making predictions is fraught with difficulty as risk does not exist independent of our minds, (Slovic 1982) and therefore "*risk is in the eye of the beholder*". (Savage 2012). Risk therefore can only be managed by utilizing past experience or as Soren Kierkegaard (1813-1855) once commented "*Life can only be understood backward: but it must be lived looking forward*" (Bouchier-Hayes 2005) If risk means different things to different people at different times it is reasonable to assume creating a risk assessment that meets the need of a variety of stakeholders will likely be problematic. Interestingly as (CHAS 2013) advise: " *It's not always easy to tell who is responsible for contractor health and safety, and everyone involved in the work activities from workers to executives, contractors and employers and business owners are expected to do what they can to minimize risk".*

This poses some interesting questions about the risk assessments purposes and its intended audience. Is the risk assessment simply intended to protect workers from workplace hazards, or is it also designed to protect the employer from criminal or civil liability, to give solace to clients, regulators, insurance companies or any other external stakeholders. This paper forms part of an ongoing research project examining the applicability, reliability, and proportionality of published risk assessments in the renewable energy sector.

2. Methodology:

This pilot study has been undertaken using a Mixed Method which offers an alternative approach by the combination of traditional qualitative and quantitative research techniques. Halcomb and (Hickman 2015). See figure 1. The source data is gathered from 100 published and 'live' task risk assessments kindly supplied by four different renewable businesses. Each task risk assessment contained a variety of hazards where the risk of realization was evaluated and scored before the application of any risk reduction measures. The risk reduction measures (1200) formed the basis of a Thematic Analysis described as descriptive method that reduces the data in a flexible way that dovetails with other data analysis models. (Vaismoradi ,Turunen, and Bondas 2013) The resulting information is then coded into NVIVO software to enable qualitative analysis. Coding simply involves researchers identifying similarities and differences in the data. Austin and Sutton (2014)

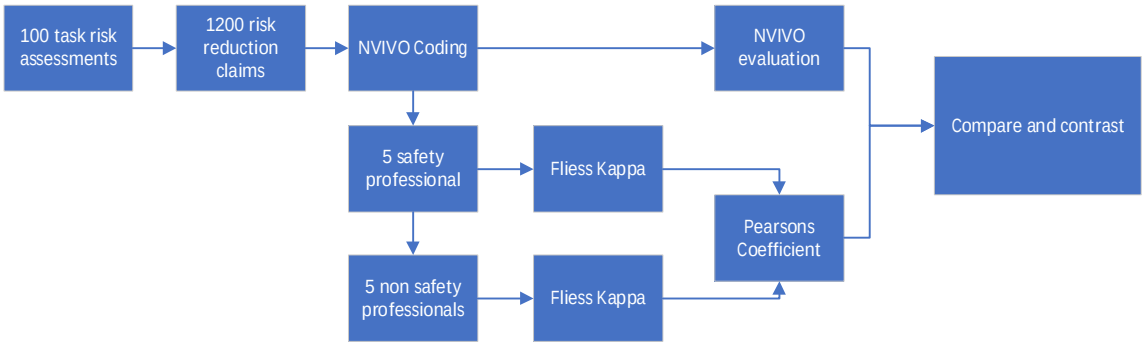

Figure 1 Overview of research model

Two groups of random volunteers were chosen, each group had no knowledge of the renewable industry and no connections to any renewable energy businesses. The first group of 5 volunteers came from the Institute of Occupational Safety and Health (IOSH). The second group of five were friends or relatives of the safety professionals who had no formal safety knowledge. It has been shown that providing the volunteers are randomly chosen the resulting median is 93.75% accurate. (Hubbard 2014) p43

Using a random number generator 25 risk reduction measures from the 1200 collected were selected and each volunteer was simply asked to indicate if the risk reduction measure could be classified using the NVIVO coding. The results were then analyzed using 'Fliess Kappa analysis which is a measure of inter-rater agreement to determine the level of agreement. (Fliess et al 2003) The results of the Fliess Kappa analysis were then used to establish if there was any correlation between the two groupings using Pearson's correlation coefficient which establishes the measure of strength of a linear association between two variables. (Leard Statistics 2020)

3. Results:

Having adopted the coding from table 1 from NVIVO the percentage categories indicate the overall theme of the published risk assessments. The descriptive nature of qualitative approaches allows the researcher to build a complex holistic picture in a natural setting. (Creswell 2007)

Table 1 NVIVO coding indicates risk assessment theme

CODING	Choices	Reference	Competency	PPE	Instruction	Statement	Unknown
%	16%	9%	15%	7%	33%	17%	3%

The Fliess Kappa result from the safety professionals, table 2, indicated a 0.512 Kappa result which is a moderate agreement as the result falls between 0.41 and 0.60. (Landis and Koch 1977). With a 95% confidence interval and a Sig value of 0.00 the result is classed as statistically significant. Laerd Statistics (2019). The results for the non-safety professionals, table 3 indicated 0.164 Kappa which is classified as a is poor level of agreement as result is < 0.20. (Landis and Koch 1977. Results showed a 95% confidence level and a Sig. value of 0.00 which is classed as statistically significant. (Laerd Statistics 2019).

Overall Agreement[a,b]

		Asymptotic			Asymptotic 95% Confidence Interval	
	Kappa	Standard Error	z	Sig.	Lower Bound	Upper Bound
Overall Agreement	.512	.031	16.576	.000	.452	.573

a. Sample data contains 24 effective subjects and 5 raters.

b. Rating category values are case sensitive.

Table 2 Fleiss Kappa result for safety professionals

Overall Agreement[a,b]

	Kappa	Asymptotic Standard Error	Asymptotic z	Asymptotic Sig.	Asymptotic 95% Confidence Interval Lower Bound	Asymptotic 95% Confidence Interval Upper Bound
Overall Agreement	.164	.033	4.940	<.001	.099	.230

a. Sample data contains 25 effective subjects and 5 raters.

b. Rating category values are case sensitive.

Table 3 Fleiss Kappa result for non-safety professionals

The full set of Kappa results were then analyzed for any correlation using the Pearson's correlation coeficient. The pearson Coeffient is demonstrated in Eq. 1.

$$r = \frac{\Sigma(x_i - x)(y_i - \bar{y})}{\sqrt{\Sigma(x_i - x)^2 \Sigma(y_i - \bar{y})^2}}$$

Equation 1 Pearson correlation coefficient

Correlations

		Safety	NSafety
Safety	Pearson Correlation	1	.249
	Sig. (2-tailed)		.590
	N	7	7
NSafety	Pearson Correlation	.249	1
	Sig. (2-tailed)	.590	
	N	7	7

Table 4 Results of Pearson coefficient analysis

Where, r is the Pearson Coefficient score, x_i and y_i are the values of the variables in the two data sets, and $\bar{x}$ and $\bar{y}$ are the mean of the values of the two data sets, x and y respectively. The Pearson correlation coefficients between the two Kappa Fliess sets of results indicates a 0.249 correlation which is classed as a small strength of association being 0.1 and 0.3. (Laerd Statistics 2020) table 4

4. Discussion and further research:

This research has identified that safety professionals will only moderalty agree on the category of the risk reduction measures used to alledgedly lower the judged risk. Those will no formal safety background had a very low level of agreement on the category of risk reduction measures indicating therefore the value of the risk assessment was moderate to low. The NVIVO analysis results further indicated that that 33% of the risk reduction measures analyzed gave the user additional instruction and a further 16% of the risk reduction measures offered choices that may or may not actually be available. Clealry the scoring of risk reduction measures therefore needs further research. Additionally it appears unclear who the target audience is for the risk assessments. There are a variety of stakeholders both internal and external to the businesses who have a vested interested in the document. These include: Engineering teams, managers, clients, regulators and end users. It could certainly be suggested on the evidence gathered to date that current and published risk assessments contain data that adds little to any genuine risk reduction approach, however by including such content the size and scale of the document gives the impression of control of the hazard and a dilligent approach to risk management to some stakeholders. This claim however requires further in depth analysis and research in order to verify

5. Conclusions:

In endeavouring to create a risk assessment that meets the expectations of multiple stakeholders the principle aims of protecting and supporting the end user has become diluted, potentially obscuring substantial risks. Frequent reference to additional instructions, PPE and competency all of which are legally mandated and potentially outside of the scope of a risk assessment implies that safety assurance systems may not be capable

of identifying issues. Therefore, it's a reasonable assumption that failure to carry out relevant safety assurance protocols is such a hidden risk. Additionally, attributing risk reductions to items that may or may not be present or offering the end user a choice as to whether a measure is adopted or not is counterintuitive and implies that a certain answer was required before the analysis and was therefore pre-defined.

The next step in the research is to create a model which utilizes evidence-based claims of risk reduction and focuses on the genuine risk faced by the end user. Risk reduction measures need to be tangible and potentially form the basis of a simple checklist which determine if the task proceeds or is stopped. Once created the new model will be evaluated in terms of proportionality, usability, and reliability to demonstrate progress.

6. Acknowledgements:

I would like to offer my sincere thanks and gratitude to Dr Sean Loughney (School of Engineering) and Paul Hanley (library services) for their continued support and guidance in in the creation of this paper

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V392 Persei: a gamma-ray bright nova eruption from a known dwarf nova

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Abstract. V392 Persei is a known dwarf nova (DN) that underwent a classical nova eruption in 2018. Here we report ground-based optical observations following the eruption for almost three years. V392 Per is one of the fastest evolving novae yet observed, with a t_2 decline time of 2 days. Early spectra present evidence for multiple and interacting mass ejections, with the associated shocks driving both the γ-ray and early optical luminosity. V392 Per entered Sun-constraint within days of eruption. Upon exit, the nova had evolved to the nebular phase. Subsequent optical emission captured the fading ejecta alongside a persistent narrow line emission spectrum from the accretion disk.
The optical data suggest a high mass WD, the pre-nova spectral energy distribution (SED) indicates an evolved donor, and the post-nova SED points to a high mass accretion rate. Following eruption, the system has remained in a nova-like high mass transfer state, rather than returning to the pre-nova DN low mass transfer configuration. We suggest that this high state is driven by irradiation of the donor by the nova eruption. In many ways, V392 Per shows similarity to the well-studied nova and DN GK Persei.

Keywords. Novae – cataclysmic variables – accretion disks

1. Introduction

Classical novae (CNe) are among the most luminous stellar transients, exceeded only by supernovae and gamma-ray bursts. CNe are binary systems in which a white dwarf (WD) accretes hydrogen-rich material from a donor star via an accretion disk (Warner 1995). Accretion proceeds via Roche-lobe overflow for the majority of CNe; those with main sequence or sub-giant donors. For CNe with giant donors, material is accreted from the giant's wind. The accreted envelope builds in temperature and pressure until a thermonuclear runaway occurs (Starrfield et al. 1976), blasting material from the WD's surface, leaving the WD and donor relatively unscathed. The CN is observed as a rapid increase in optical luminosity of 10–15 magnitudes, followed by a slower decline.

CNe are a sub-type of cataclysmic variable (CV), a class that also includes dwarf novae (DNe). DN outbursts are less luminous than CN eruptions and are powered by the release of gravitational potential energy, which can occur when hydrogen-rich material in the accretion disk is suddenly deposited onto the WD. DN outbursts are produced in systems where the accretion rate (ΔM) is lower than the critical rate (Smak 1983), due to thermal or tidal instabilities within the disk (Osaki 1996).

Abdo et al. (2010) first reported detection of γ-ray emission from a nova; the V407 Cygni ejecta shocked surrounding circumstellar wind, accelerating leptons to relativistic velocities and emitting γ-ray photons of energy > 100 MeV. Since that initial discovery, γ-ray signatures have been exhibited in increasing numbers of classical novae (see Aydi et al., 2020b; Chomiuk, Metzger & Shen 2021, for recent reviews). Several γ-ray detected novae occurred in systems with red giant donors: e.g., V407 Cyg and V1535 Sco (Franckowiak et al. 2018). In these systems, the

shocks generating the γ-rays are likely to originate in collisions between the nova ejecta and the dense red-giant winds and circumbinary material. However, the other γ-ray emitting novae have main sequence companions and are unlikely to be surrounded by dense winds. In these systems, the shocks are proposed to be due to interaction between multiple ejection components (Aydi et al. 2020b). Studies suggest that the γ-ray and optical emission can show correlated peaks, with the shocks driving the optical emission (Ackermann et al. 2014).

A number of CVs have been observed to undergo both CN eruptions and DN outbursts. For example, GK Per (Bianchini et al. 1986; Zemko et al. 2017) and V446 Her (Honeycutt, Robertson & Kafka 2011) are CNe that subsequently underwent DN outbursts. Z Cam and AT Cnc are known DNe surrounded by proposed ancient CN shells (Shara et al. 2007, 2012). V1213 Cen and V1017 Sgr exhibited DN outbursts six and eighteen years, respectively, before a CN (Mróz et al. 2016).

V392 Persei was a known CV with a few observed DN outbursts, with quiescent magnitude of $V > 17$ (Zwitter & Munari 1994). Its CN eruption was discovered on 2018 Apr 29 (UT) by Y. Nakamura, with an unfiltered brightness of 6.2 mag (Wagner et al. 2018). The following day, γ-ray emission was detected from V392 Per ($> 6\sigma$; Li, Chomiuk & Strader 2018), with detections continuing for 11 days (Gordon et al. 2021).

In this work, we present panchromatic data from the 2018 nova eruption of V392 Per and its subsequent evolution. We analyse the data to determine key eruption parameters.

2. Data and Methodology

2.1 Photometry

Observations of V392 Per were obtained by the fully robotic 2.0 m Liverpool Telescope (LT; Steele et al. 2004) on La Palma. LT images were taken with the IO:O instrument through $u'BVr'i'z'$ filters. Additional i'-band photometry was collected using both Las Cumbres Observatory 1.0 m Telescopes at McDonald Observatory in Fort Davis, Texas. We also used optical photometry from the American Association of Variable Star Observers (AAVSO). The LT and LCOGT data were reduced using standard tools within PyRAF (Science Software Branch at STScI 2012) and aperture photometry was performed using qphot. The data were calibrated against 25 reference stars in the field, selected from the Pan-STARRS catalogue (DR1).

2.2 Spectroscopy

LT spectra were collected using SPRAT (with a spectral resolution $R \approx 350$; Piascik et al. 2014, blue-optimised mode) and FRODOSpec. The resolving power of the FRODOSpec red arm was $R \approx 2200$ or $R \approx 5300$, and the blue arm was $R \approx 2600$ or $R \approx 5500$. These spectra were reduced using the LT pipeline; producing bias subtracted, flat-fielded, wavelength calibrated, sky-subtracted products. Optical spectra of V392 Per were obtained with the 2.4 m Hiltner telescope of the Michigan-Dartmouth-MIT (MDM) Observatory on Kitt Peak. The Hiltner spectra were obtained using the Ohio State Multi-Object Spectrograph (OSMOS). All aforementioned spectra were absolute flux calibrated using interpolated $BVr'i'$ photometry.

3. Results

3.1 Photometry

The V-band light curve of V392 Per is shown in Figure 1a. The light curves in the other optical passbands exhibit a similar shape. From the fit to the V-band light curve, we measured t_2=2.0 days, the time for the nova to decline by 2 magnitudes from its maximum brightness. This means the light curve evolution is very fast, which often indicates the presence of a high mass WD. Figure 1b compares the flux of the V-band observations with the gamma-ray flux detected by Fermi-LAT during the early days of the eruption. There appears to be a clear correlation between the gamma-ray

and optical emission during the early evolution, as has been reported for other gamma-ray novae (Ackermann et al.2014, Aydi et al. 2020a).

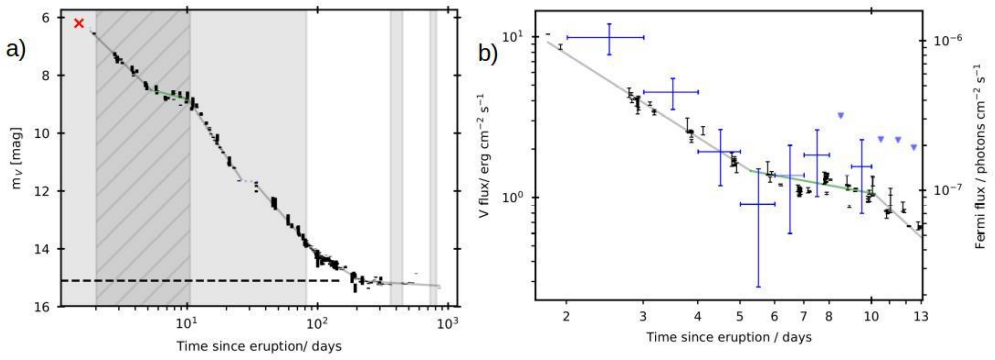

Figure 1a) (left) showing the V-band light curve for V392 Per. The data points are shown as black error bars, with the best fit to the light curve shown. The light grey vertical shaded regions indicate the time when the system was in Swift Sun constraint. The dark grey shaded region indicates the time when gamma-rays were detected by Fermi-LAT. The red cross indicates the time and unfiltered magnitude of discovery. The horizontal dashed line indicates the magnitude of a neighbouring star. Figure 1b) (right) showing the flux of the V-band observations as black data points, and the gamma-ray flux detected by Fermi-LAT as blue data points. The blue inverted triangles indicate 95% confidence upper limits of gamma-ray flux. The Fermi-LAT flux measurements are taken from Albert et al. (2022).

2.2 Spectroscopy

Figure 2a presents spectra taken before V392 Per entered its first Sun constraint. Emission lines present in the spectra were identified. Species present included hydrogen Balmer lines, He I, Fe II. The interstellar absorption Na doublet line was also present. The spectra revealed high velocities, which are indicative of a high mass WD. Early Balmer line spectra contained P Cygni profiles with two or more absorption features. Measurements of the velocities indicated the movement of different ejecta components which collided, producing shocks which powered the gamma-ray emission.
When the system emerged from its Sun constraint, it had entered the nebular phase. [OIII] emission lines appeared, as did He II. Flux measurements of these key lines are shown in Figure 2b.

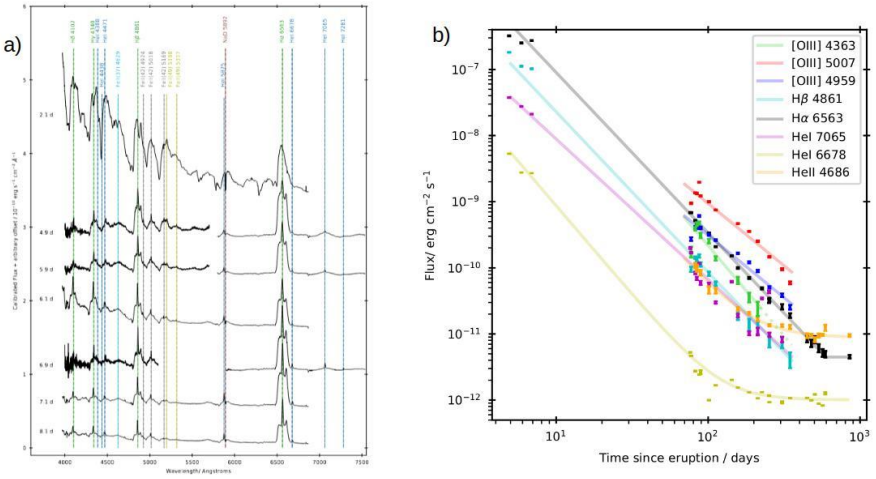

Figure 2a) (left) displaying the early spectra of V392 Per, taken before the first Sun constraint. Flux calibrated, de-reddened spectra from LT and Hiltner 2.4 m are shown. Prominent spectral features are labelled, with the time since eruption for each spectrum indicated on the left of the plot. Figure 2b) (right) shows the flux measured for

key spectral species that were present in the spectra, focusing on those that were present when V392 Per emerged from its Sun constraint.

4. Summary and Conclusions

V392 Per is a known CV, which exhibited month-long GK Per-like DN outbursts, and its only known classical nova eruption was discovered on 2018 April 29. Panchromatic photometric and spectroscopic follow-up took place, with optical observations intensifying after the reported detection of γ-rays by Fermi-LAT, although the system was already in Swift Sun constraint at eruption. Post-Sun constraint, the eruption had entered the nebular spectral phase and Swift observations began. Since $\sim$ 250 days post-eruption, V392 Per has remained in a high state, consistently $\sim$ 2 mag brighter than the pre-eruption quiescent minimum. Here we summarise our key findings:
(i) With $t_2 = 2.0 \pm 0.2$ days, the eruption is classed as 'very fast', indicative of a high mass WD.
(ii) The early spectra indicate that V392 Per is a rare Fe ii-broad class, with ejection velocities up to 5000 km $s^{-1.}$
(iii) Evolution of early-time H alpha P Cygni profiles strongly suggest there were two distinct mass ejections, with the higher velocity second ejecta running into and shocking the first.
(iv) These inter-ejecta, and subsequent intra-ejecta, shocks drove the γ-ray emission.
(v) Distinct similarities between the γ-ray and early optical evolution suggest that the early luminosity was powered by the shock emission.
(vi) Optical spectra show two distinct contributions: a broad initially triple, then double peaked fading ejecta spectrum; and a narrow lined and persistent accretion disk spectrum.

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Bio-mineralisation to enhance the characteristics of polymer modified concrete for chloride environments

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Abstract

This research compares the performance of three types of polymers modified concrete (TPE, LDPE/EVA and PCL) if bacteria-based solutions are used for reinforced concrete (RC) structures designed for a compressive strength higher than 50 MPa for chloride environments. The aim is to understand the impact on mechanical and durability performance of concrete. These recyclable polymers use is crucial to increase the strength at 28 and 60 days. At 60 days, all polymer modified concrete reached a compressive strength higher than 65MPa, no matter if bio-agent is added or not. The use of bio-agent is crucial to create a drop in the open porosity values to 4%. However, the use of bio-agent tends to delay the increase of concrete compressive strength with time, especially until the 14 days. The existence of tetrahedron and pyramid structures in polymer modified bio-concrete indicates that calcite is present and the quantity of calcium carbonate in the polymer modified bio concrete is significantly higher than in plain bio concrete or even plain.

Keywords: Self-healing concrete, Durability, Polymer, Maritime, Sustainability

1.0 Introduction

RC structures are highly affected by maritime environments, de-icing salts, moisture, and industrial chemicals, leading to structural deterioration. Polymer modified concrete is manly used in bridge decks, post-tensioned beams and slabs, in pipes for the transport of fluids, storage tank for seawater, hazardous waste containment, among others. The polymers can be added into the concrete mixture as partially sand replacement, to strength the cement hydrate binder. The objective of the polymer is to fill the voids of concrete and preventing the free water movement usually found inside the voids of this porous medium [1]. Several factors affect the performance of concrete with polymer incorporated and only a few types of polymers could be implemented in wet concrete repair. Concomitantly, the structure service temperature needs to be taken into account as it can have a severe impact on the properties of the polymer modified concrete [2]. It is estimated that the optimum amount of polymer to be added needs to be between 7.5-20% of the dry polymer solids/ cement mass. Too much polymer might damage concrete, leading to air entrainment and promoting a mechanical behaviour of the concrete more closed to a polymer. A very low quantity of polymer in the concrete can slow down the development of the mechanical properties expected for the concrete [3]. Concrete mixes properties with different types of polymers have been studied and reported. Thermoplastics are the most frequently used in concrete to partially replace coarse or fine aggregates, including polyethylene terephthalate (PET), low and high-density polyethylene (LDPE and HDPE), polyvinyl chloride (PVC), polypropylene (PP) and polystyrene (PS), etc. The importance of polymer composites in the concrete industry is emphasized with the substantial number of topics related to polymers that can be found in the European standards, namely the EN 1504. Their chemical resistance tends to be better than ordinary concrete. However, several important properties such as strength, bond and durability performance of concrete and cement mortar are negatively affected if plastic is added [4, 5]. Using bio-mineralisation techniques it is possible to overcome these challenges [6, 7].

Bio-mineralisation is a process used by bacteria to produce minerals to stiffen or harden construction materials, namely cement-based ones, sealing the cracked walls to reduce permeability [8, 9, 10]. This

bio-technological healing method makes use of certain bacteria's ability to induce the calcium carbonate formation within the cementitious matrix. The working theory is that these bacteria can produce calcium carbonate precipitations as well as biologically induced chemical precipitations, allowing the organism to develop a perfect mineral phase extracellular micro-environment known as bio-mineralisation. The metabolic route for the formation of calcium carbonate can sometimes affect the corrosion of cement-based materials [8, 10-12]. The precipitation of $CaCO_3$ can happen in three different polymorphic forms: calcite, aragonite and vaterite. $CaCO_3$ precipitation is induced through different bacterial mechanisms, namely: iron reduction, urea hydrolysis, sulphate production or denitrification [13].
The use of bacteria-based solutions to complement the polymer modified concrete might be an opportunity by potentially enabling the re-use or increase quantity of polymers incorporated and simultaneously taking advantage of polymers elastic/ductile properties to heal concrete cracks in a complementary way to the calcium carbonate formed due to bacteria metabolism. This research work intends to compare the performance of polymer modified concrete if bacteria-based solutions (bioproduct) are mixed in the concrete for RC structures and understand the impact on the final physical and mechanical performance of concrete.

2. Materials

Ordinary Portland cement (OPC) type CEMI 52.5N was used in accordance with BE EN 197-1: 2011. The OPC was supplied by Hanson Cement in the UK. The sand used within this study comes from Tarmac Plant, UK, according to the BS EN ISO9001. Coarse aggregates were supplied by Specialist Aggregate and Travis Perkins in the UK, the aggregate sizes were 10 and 20mm. A total of three different types of thermoplastic polymers were selected to be used within this study. The studied polymers are thermoplastic elastomers (TPE), low density polyethylene/Ethylene-vinyl acetate copolymer (LDPE/EVA) and ε-polycaprolactone (PCL). A bacterial *Shewanella*-like strain was used as abio-agent, with a ratio of 2.1%/binder (Figure 4). This iron-respiring bacteria can grow over a wide pH range 5.6~9.4 and has the highest grow rate temperature range between 34~35°C.

3. Immobilising the bio-agent for concrete preparation

The main aim of this research was to adhere the bio-product to the polymer surface and/or impregnate the polymer pores, for that purpose 3% of polymer (by weight of sand) (TPE, LDPE/EVA and PCL) by mass was mixed with the bio-agent and nutrient. Then the bio-agent and polymer mixture were placed in a bench top shaking incubator for 1 hour at 30°C and 200rpm/minute, then mixed with fresh concrete then mixed with fresh concrete. Table 1 shows the concrete mix design.

Table 1 - Concrete mix design quantities Kg/m^3.

Compositions	CEMI	Agg 20	Agg 10	Sand	Polymer	Water	w/c	Bio-agent
Plain	450	712	610	335	-	180	0.4	0
CEMI + 3% polymer	450	712	610	324.95	10.05	180	0.4	0 and 50ml

4. Laboratory experiments

The experiments carried out to evaluate the mechanical and durability properties of concrete at various ages are summarised in table 2.

Table 2- Procedures and standards of the laboratory test.

Test	Procedure/ standard	Testing days
Slump	BS EN 12350-2:2009. The consistency of fresh concrete was analysed for all concrete mixtures.	0
Compressive strength	BS EN 12390-3:2019, in 100mm concrete cubes were loaded to failure, in compliance with EN 12390-4.	7, 14, 28 and 60
Open porosity	BS EN 1936: 2006	28 and 60

5. Results and discussion

Hardened state properties of concrete are highly depended on its workability. The slump test was performed in order to quantify the effect of the microbial self-healing agents on the workability of fresh concrete. Figure 1 shows 3% polymer modified concrete leads to an improvement in slump by 4% in comparison to plain sample, which corresponds to a consistency class of S3, enabling the concretes to be used for normal RC, manually compacted and heavily reinforced sections with vibrations.

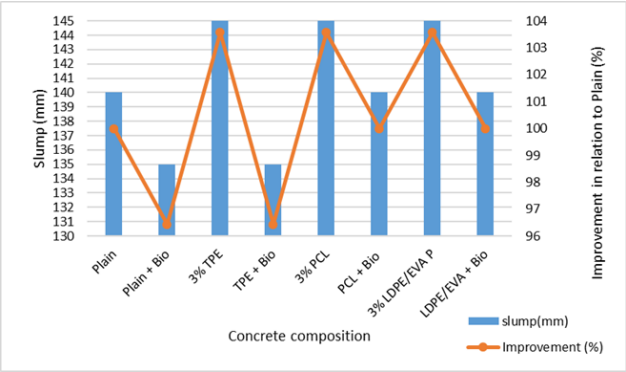

Figure 1 - Slump values for plain concrete, concrete with polymers and concrete with polymer plus bacteria.

This slump increase in comparison to plain concrete composition is explained by the small size and smooth polymers surface when compared to sand. According to Sakia and de Brito [14], polymer form and surface texture have a direct impact on the fresh concrete. It is also observed that the use of bio-agent in polymer modified concrete tend to slightly decrease the slump to values similar to plain composition in the case of TPE+bio. For PCL+bio and LDPE/EVA+bio concrete composition, the slump results are slightly smaller than for the polymer concrete without bioproduct. This means that the slump results with the use of bio-agent are still very competitive leading only to small modification of concrete workability.

Figure 2 shows the compressive strength results at 7, 14, 28 and 60 days, for all three groups of concrete including plain, plain with polymer, plain with polymer and bacteria.

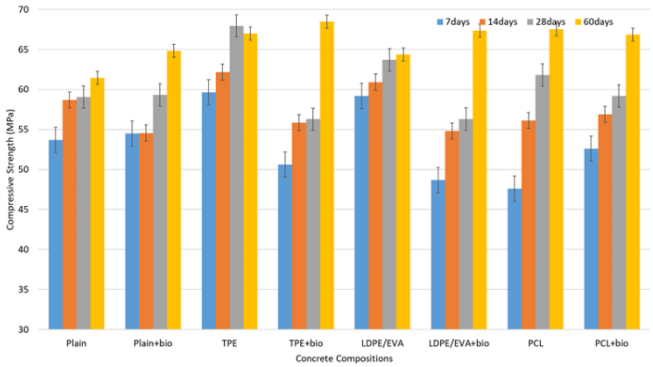

Figure 2 - Compressive strength results at 7, 14, 28 and 60 days for plain, concrete with polymers and concrete with polymer and bacteria.

It can be shown that the use of bio-agent tends to delay the increase of compressive strength with time, especially until the 14 days. However, despite the 28 days results are not yet at the same level as the ones obtained for the polymer modified concrete compositions, the compressive strength results for the concretes with bio-agent seem to keep growing and eventually reach a similar compressive strength to the ones without bioproduct. At 60 days, all polymer modified concrete reach 67MPa of compressive strength, no matter if bio-agent is added or not, except for LDPE/EVA, where the addition of bio-agent substantially increases the compressive strength to 67MPa. Adding the bio-agent to the plain concrete composition leads to similar 28 days strength, despite at 14 days the results are lower than for the plain composition. This might be associated with a delay of cement hydration due to the presence of

bioproduct. At 28 days, the highest compressive strength (68MPa) is obtained if TPE is modified in the concrete, and despite TPE lower density (0.88g/cm^3), the coefficient of variation (COV) of concrete compressive strength was only of 2%. At 28 days, TPE with bio-agent (COV=4%) leads to a decrease of the concrete compressive strength of 17%. With LDPE/EVA, the bio-agent leads to a decrease of 12% in the compressive strength and, for PCL the decrease is only of 4% in comparison to the concrete without the Bio. COV was very low for low density polymer modified concrete (LDPEEVA concrete presented a COV=3%). However, for higher density polymer, PCL concrete, COV=7%.

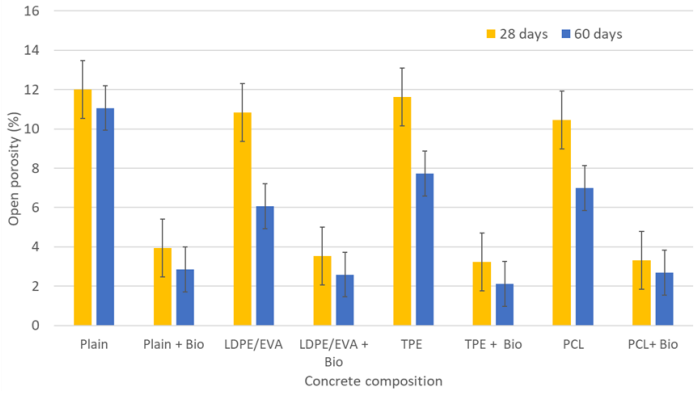

Figure 3 - Open porosity values for plain, concrete with polymer and concrete with polymer and bacteria at 28 and 60 days.

Figure 3 presents the comparison between the porosity at 28 and 60 days for the concretes with polymer modified and the ones with an addition of bioproduct. At 28 days the small amount of polymer decreases porosity up to 1% in comparison to plain concrete. However, the most impressive results happen if bio-agent is added. The results show that the use of bio-agent leads to an impressive decrease of porosity from 12% to 2-3%. This reduction of the quantity of concrete pores will probably be associated with a reduction of capillary suction - related to pores transport of O_2 and CO_2 - and diffusion (related to the transport of water and ions as chloride.

At 60 days, all concrete compositions modified with polymer decrease the porosity to values to values around 3-4%. The bio-agent accelerates that decrease in a more effective way than polymers, which is probably associated with a densification of the concrete matrix due to bio-mineralisation. Permeability is reduced when the pore network is finer and less connected. On the other hand, a porous microstructure with a higher degree of interconnectivity results in higher permeability and, in general, worse durability.

6. Conclusions

This research work intends to compare the performance of three types of polymers modified concrete (TPE, LDPE/EVA and PCL) if bacteria-based solutions are used for RC structures designed for a compressive strength higher than 50 MPa. The aim is to understand the impact on the final mechanical and durability performance of concrete. The work shows that: It is possible to incorporate thermoplastic polymers into concrete to increase the strength, electrical resistance and decrease chloride migration. However, the use of bio-agent is crucial to create a drop in the open porosity values at that 28 and 60 days, from 12% to 4%. At early stages, the concrete with PCL benefits from the use of bio-agent as the compressive strength easily reaches the 50MPa at 7 days. However, the use of bio-agent tends to delay the increase of concrete compressive strength with time, especially until the 14 days. At 28 days all concretes present values above 55MPa. For LDPE/EVA, addition of bio-agent substantially increases the compressive strength to 67MPa.

Acknowledgements

The authors of this paper would like to thank the Royal Society research grant RGS\R1\191304—Research Grants 2019 Round 1, ICE R&D Enabling Fund, and Royal Academy of Engineering for enabling the development of this work.

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An Hα survey of the environments of nearby type IIn supernovae.

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Abstract. Type IIn supernovae (SNe IIn) are an uncommon and highly heterogeneous class of SN where the SN ejecta interact with pre-existing circumstellar media (CSM). Previous studies have found a mass ladder in terms of the association of the SN location with Hα emission and the progenitor masses of SN classes. In this paper, we present the largest environmental study of SNe IIn. We analyse the Hα environments of 77 type IIn supernovae using continuum subtracted Hα images. We use the pixel statistics technique, normalised cumulative ranking (NCR), to associate SN pixels with Hα emission. We find that our 77 SNe IIn do not follow the Hα emission. This is not consistent with the proposed progenitors of SNe IIn, luminous blue variables (LBVs) as LBVs are high mass stars that undergo dramatic episodic mass loss. However, a subset of the NCR values follow the Hα emission, suggesting a population of high mass progenitors. This suggests there may be multiple progenitor paths with ~60% having non-zero NCR values with a distribution consistent with high mass progenitors such as LBVs and ~40% of these SNe not being associated with Hα emission. We discuss the possible progenitor routes of SNe IIn, especially for the zero NCR value population. We also investigate the radial distribution of the SNe in their hosts in terms of Hα and r'-band flux.

Keywords. Supernovae; circumstellar material

1. Introduction

First categorised by (as Seyfert I SNe [1]) and [2], type IIn supernovae (SNe IIn) account for around 7% of the total SN population. SNe IIn are generally spectroscopically characterised by a narrow feature on the Balmer series (most obvious on the Hα line) with full width half-maximum (FWHM) ~10^{2} km s^(-1) [3]). This narrow feature is superimposed on an intermediate width (FWHM ~10^3 km s^(-1)) and/or a broad component (FWHM ~10^(3-4) km s^(-1)). These characteristic narrow features originate from the SN ejecta shocking pre-existing, dense, cold, and slow circumstellar medium (CSM) with CSM densities ~10^(-13)-10^(-15) gcm^(-3). A Hα excess is created when emission from this interaction ionises the surrounding, unshocked, CSM and then recombines. The broader components originate from the SN ejecta. The intermediate components may originate from interaction with a massive and dense, clumpy wind, possibly further broadened by Thompson scattering. SNe IIn often lack the P-Cygni features seen in other SN classes and have a blue continuum which may originate from the strong CSM interaction.

The CSM surrounding a SN IIn progenitor comes from the progenitor itself or, in some cases, a companion star. The progenitor may experience mass loss episodes toward the end of its life [4]. LBVs may expel material through massive winds and more dramatic episodic eruptions. The mass loss rates from eruptive episodes, such as the great eruption of eta Car in the 19th century, can be as high as 1 M_(odot) yr^(-1), which can lead to ejected envelopes with masses as high as 10 M_(odot) [5]. LBVs are observed progenitors of at least one SN IIn, SN 2005gl in NGC 266 [6].

1. The title, author list and abstract

We use the Liverpool Telescope (LT) and Isaac Newton Telescope (INT) at the Observatorio de Roque de las Muchachos on La Palma in the Canary Islands, and the Las Cumbres Observatory 2m (LCOGT\2m) at Siding Springs Observatory, New South Wales, Australia for our observations.

Our observations consist of 3 x 300s exposures using the appropriate redshifted Hα filter and a single 300s exposure with in the r'-band with 2 x 2 binning. These observations span 2019 to 2021. We limit our observations to nearby ($z<0.02$) hosts as we require that HII regions are resolved for the pixel statistics used. Furthermore, we select hosts with axial ratios of under 4:1 to ensure the SN IIn site is associated with the observed emission, rather than possibly coincident as may be the case in a more edge-on galaxy. Major and minor axes for each host were taken from the SIMBAD Astronomical Database. Both IO:O and Spectral have a 10' field of view and all surveyed hosts were contained within the field of view. The LT has redshifted Hα filters covering the range to around $z = 0.04$ and all of our targets are within $z = 0.02$. We only use the LCOGT 2m for nearby targets as there is only a rest-frame Hα filter.

Raw data from the LT and LCOGT 2m are reduced by the respective standard pipelines. The NCR analysis requires continuum-subtracted images. We use the methods in [7] (and references therein), using IRAF, astropy and specutils. Data from the INT was reduced using standard procedures using astropy.

We then use the pixel statistics technique, normalised cumulative ranking to associate the SNe positions with Hα emission.

2. Formatting the text

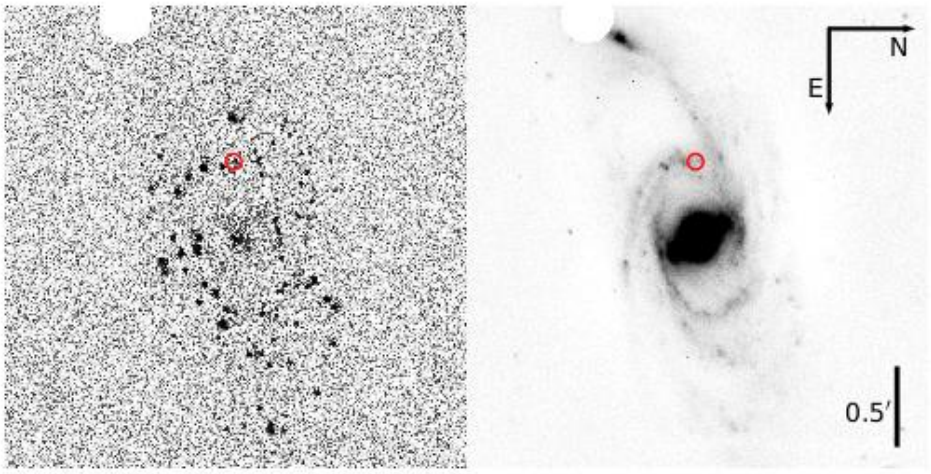

Figure 1: The continuum-subtracted Hα (left) and r'-band (right) environments of PTF 11iqb in NGC 151 (z=0.0126). The position of PTF 11iqb is marked with the red circle. PTF 11iqb is an example of a SN IIn associated with star-formation as traced by the Hα emission, resulting in an NCR value of 0.845. The foreground star at the top of the image has been masked out in the Hα image as the continuum subtraction leaves artefacts which may interfere with the NCR value calculation.

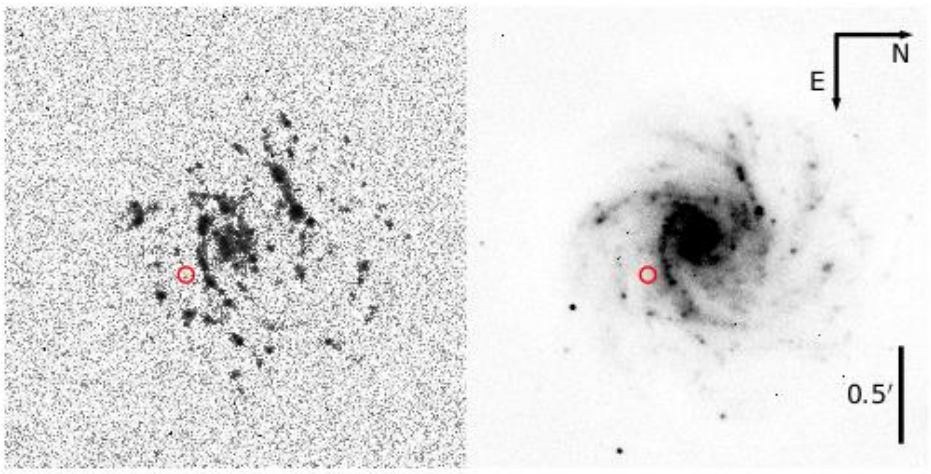

Figure 2: The continuum-subtracted Hα (left) and r'-band (right) environments of SN 2003lo in NGC 1376 (z=0.0139). The position of SN 2003lo is marked with the red circle. SN 2003lo is an example of a SN IIn that is not associated with star-formation as traced by the Hα emission (NCR value of zero). In the case of SN 2003lo, the transient resides in an apparent inter-arm gap.

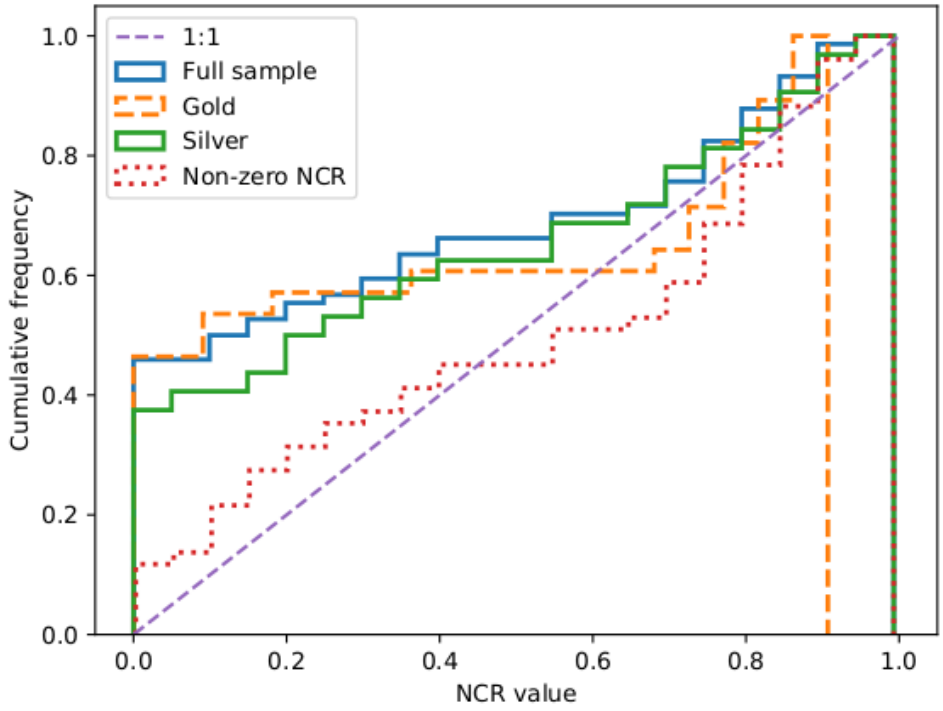

Figure 3: Cumulative distribution of the NCR values of the subsamples of our SNe IIn environments. The solid blue line is the full sample, the orange dashed line is the gold sample, the solid green line is the silver sample and the red dashed line is the non-zero NCR value sample. Also plotted is the 1:1 relationship (purple dashed line) which represents a population of progenitors which are strongly associated with star formation as traced by Hα emission.

1. Summary

We have presented the results of the largest environmental study of SN IIn hosts to date with 77 SNe IIn with most having a strong spectral classification. Our conclusions can be summarised as:

- We found that as a whole, SNe IIn do not follow star-formation as traced by Hα emission.
- We find that around 40% of SNe IIn are not associated with any SN IIn emission as calculated by NCR.
- The non-zero NCR population is consistent with the hypothetical star-formation following population.
- Our findings suggest there may be multiple progenitor routes to SNe IIn (e.g. ecSNe or SNe Ia-CSM). We do not see bimodality in our NCR distributions but we see multimodality in the full sample and non-zero NCR value subsample.
- There are no significant differences in the NCR distributions of the gold and silver classes. This suggests that many of the silver SNe IIn may be promoted to gold SNe IIn given more spectra.

Future surveys will provide a huge amount of data and transient discoveries. Surveys such as the ZTF and the Legacy Survey of Space and Time (LSST) at the Vera C. Rubin Observatory will provide a wealth of SN IIn candidates and will allow much larger samples to be used for constraining possible SN IIn progenitors.

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Boosting and accelerating benefits of sugarcane bagasse ash in concrete production by means of mechanical activation.

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Abstract. Efforts are made to incorporate industrial waste in form of ashes in the production of more sustainable concrete. In previous research, the use of untreated sugarcane bagasse ash demonstrated to be an enhancer of durability-related properties increasing the chlorides penetration resistance. However, some drawbacks such as the reduction on the workability, the high-water demand and the delayed occurrence of the positive influence of SCBA were identified. This research showcases the results obtained after subjected SCBA to a mechanical treatment aiming to counteract the mentioned drawbacks. The treatment resulted in the improvement of workability and reduction of water demand. In the hardened state, it boosts and accelerates the strength gains, i.e. at 14 days, the compressive strength of concretes using a 20% of treated ashes outperformed that of plain concrete at 28 days. In terms of durability, at 28 days, the chloride penetration resistance is increased up to 58.8% with values that untreated SCBA (with lower workability) only achieves after 240 days. Therefore, treating SCBA not only neutralise the handicaps of using untreated SCBA, but enables to produce more resistant and durable concretes.
Keywords. Sugarcane bagasse ash, Waste materials, concrete durability, circular economy.

1. Introduction

Building materials and construction sector represent around 11% of all annual global CO_2eq emissions, and it is expected the demand of the former will double in the years to come, driven by concrete. The increasing global demand, the high emissions of cement production (7% of the world's CO_2 emissions) and the water and natural aggregates demand (which extraction is responsible of severe habitat, territory and infrastructures deteriorations and conflicts [1-3]) make necessary to reduce the environmental impact of concrete production and usage. Researchers have found in industrial waste in form of ashes, alternate resources to partially replace cement and fine aggregates. However, ashes present drawbacks derived from the combustion processes -high content of porous particles, organic matter, and other undesirable substances- that may hinder the possibilities of using SCBA in the production of cementitious materials reducing the workability, increasing the water demand, and ultimately reducing the compressive strength of concrete.

This is the case of sugarcane bagasse ash (SCBA) -the resulted waste of the combustion of the most produced crop in the world for energy purposes-, which use as fine aggregates substituent in concrete production is investigated in this research. In a previous stage [4], it was observed that, the use of untreated SCBA (Ut-SCBA) as fine aggregate replacement highly improved the chloride penetration resistance of concretes after 60 days. However, at 28 days, only 10% of substitution rate (SR) resulted in an increase of the compressive strength (CS). This agrees with other research outcomes where reductions in CS were obtained for SR higher than 10% [5]. It is worth noting that same w/b ratio (binder equals the sum of cement and ash) was used for all mixes and, those containing Ut-SCBA experienced dramatic drops in workability due to the existence of porous particles despite the absolute higher water demand. Slump values of 55, 40 and 35 mm were obtained for 10%, 20% and 30% SR, respectively, versus 90 mm for the control concrete (0% SR). Therefore, using additional amounts of water to achieve the same workability would result in a decrease of the ultimate CS and high-water consumption. A common technique is to partially remove porous charcoal particles by sieving, although this is not completely effective and produce further discards.

This research paper shows the results of using treated SCBA (T-SCBA) in the production of concrete aiming to neutralise the drawbacks of using Ut-SCBA. The objectives were: i) to increase the compressive strength of concrete, ii) to improve the workability, iii) to not increase the water demand

and to deepen the use of SCBA as fine aggregate replacement, little addressed by researchers with no clear outcomes [5,6]. To the knowledge of the authors, this is the first time that this type of treatments is applied for SCBA in fine aggregates substitution and the durability properties investigated. The treatment used resulted from an intermediate stage to find the optimum-one.

2. Materials and methods

2.1. Materials

Ordinary Portland Cement, OPC, CEM I, 52.5 N, as per BS EN 197-1: 2011, <600 mμ natural dried sand, 10mm and 20mm aggregates as per BS EN 12620:2002+A1:2008 and industrial sugarcane bagasse fly ash (SCBA) was used. To counteract the drawbacks of using Ut-SCBA, ashes were treated by mechanically activation, breaking down the porous particles and refining the material, Figure 1. Table 1 shows chemical and physical composition of Ut-SCBA, T-SCBA, sand and cement. When grinding, the size of particles approach to that of cement and the bulk density, and the specific surface area (SSA) increase. The sum of silicon dioxide, aluminium oxide and iron oxide (S+A+F) increases with the treatment; however, it is lower that the limit (70%) stipulated in BS EN 450-1:2012 [7] standard for fly ash for concrete. This limit is commonly observed when potential pozzolans are investigated as cement substitutes due to the similarities with fly ash (pulverised coal fly ash with or without co-combustion materials). Therefore, T-SCBA is used as fine aggregates substitution.

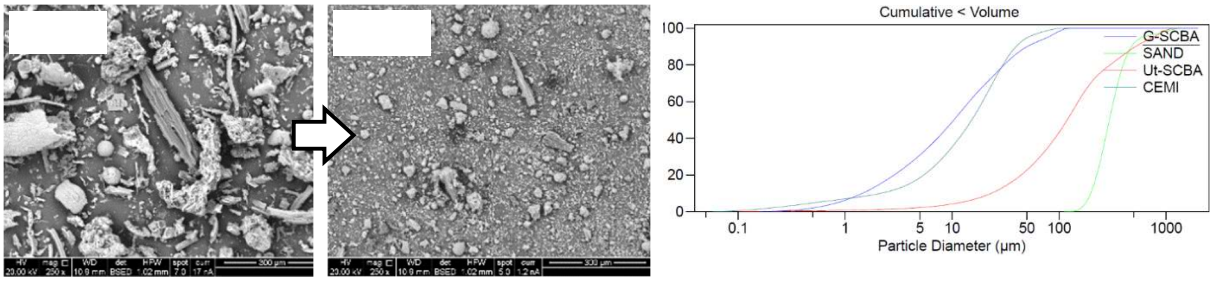

Figure 1. Appearance by means of SEM and particle size distribution of Ut-SCBA and T-SCBA.

Table 1. Chemical and physical data of ashes, sand, and cement.

	Main oxides					pH	$\%_{Amorphous}$	Particle size distribution					Real density (kg/m^3)	Bulk density (kg/m^3)	SSA (m^2/kg)
	CaO	SiO_2	Al_2O_3	Fe_2O_3	S+A+F			Mean μm	Median μm	D_{10} μm	D_{50} μm	D_{90} μm			
Ut-SCBA	13.08	48.08	6.07	5.92	**60.07**	12.56	80.7	221	131	25.5	130.8	613.8	2449	718	442.8
T-SCBA	13.90	53.17	7.11	6.01	**66.29**	12.97	81.2	19.5	10.4	1.5	10.4	50.5	2551	928	817.1
Sand	0.29	76.45	3.21	0.27	-	-	-	333	296	198	296	476	2420	1635	36.0
Cement	76.56	18.68	3.25	3.11	25.04	-	-	19.1	15.3	2.2	15.3	39.6	3150	1400	163.5

2.2. Methods

Four bio-concrete mixes were casted using T-SCBA as fine aggregate replacement (substitution rates: 0%, 10%, 20% and 30% by weight, labelled as Con, T-$SCBA_{10}$, T-$SCBA_{20}$ and T-$SCBA_{30}$, respectively, table 2) and constantly cured in water until testing according to table 3.

Table 2 Mix design.

	OPC kg/m^3	Agg. Ø20 kg/m^3	Agg. Ø10 kg/m^3	Sand kg/m^3	Ash kg/m^3	Water kg/m^3	w/b	w/c	Slump mm
Con	450	712	610	335	0	203	0.45	0.450	90
T-$SCBA_{10}$	450	712	610	302	34	206	0.425	0.457	95
T-$SCBA_{20}$	450	712	610	268	67	207	0.4	0.460	85
T-$SCBA_{30}$	450	712	610	235	101	234	0.425	0.520	90

Table 3. Concrete testing summary table.

Concrete performance	Tests	Age (days)
Consistency (Slump test)	BS EN 12350-2	0
Compressive strength	BS EN 12390-3:2019	7, 14, 28, 56, 90
Capillary water absorption	BS EN 1015-18:2002	7, 14, 28, 56, 90
Total open porosity	BS EN 1936:2006	7, 14, 28, 56
Chloride migration	NT Build 492	7, 14, 28, 56
Surface electrical resistivity	Wenner four-probe system	7, 14, 28, 56, 90

3. Results and discussion

Main results of concretes performance are shown in figure 02. In terms of compressive strength (CS), increases were obtained for all specimens containing T-SCBA since early ages (4.1%, 15.8% and 5.5% at 28 days for T-$SCBA_{10}$, T-$SCBA_{20}$ and T-$SCBA_{30}$, respectively, and 15.0%, 16.7% and 23.3% at 90 days) in comparison to the control concrete, figure 02(a). At 14 days, T-$SCBA_{20}$ specimens outperformed the CS of control specimens at 28 days by 6.28%. Additionally, increasing trends are observed in all mixes containing T-SCBA due to the ongoing pozzolanic reaction, while for the

control mix the trend flattens after 56 days. In terms of durability, it was found that the higher the substitution rate the higher the superficial electric resistivity and the lower the diffusion of chloride ions, therefore, the higher the chloride ions penetration resistance (CPR). Rapid chloride migration test shows that the use of T-SCBA highly reduces the non-steady state diffusion of chloride ions (D_{nssm}) through the concrete specimen since early ages, figure 02(b). Reductions of 38.2% (D_{nssm}=12.1x10^{-12} m^2/s), 48.5% (D_{nssm}=10.0x10^{-12} m^2/s) and 58.8% (D_{nssm}=8.1x10^{-12} m^2/s) were observed at 28 days while, for Ut-SCBA such D_{nssm} values were only achieved after 240 days [4]. By regression analysis, correlations (power trendline) were found between D_{nssm} and superficial electric resistivity (SER) in which the higher the substitution rate is, the steeper the superficial electrical resistivity curves are, turning away from the control concrete curve figure 02(b). Similar curves were found when correlated D_{nssm} to CS figure 02(c). In all cases, R-squared was higher than 0.9.

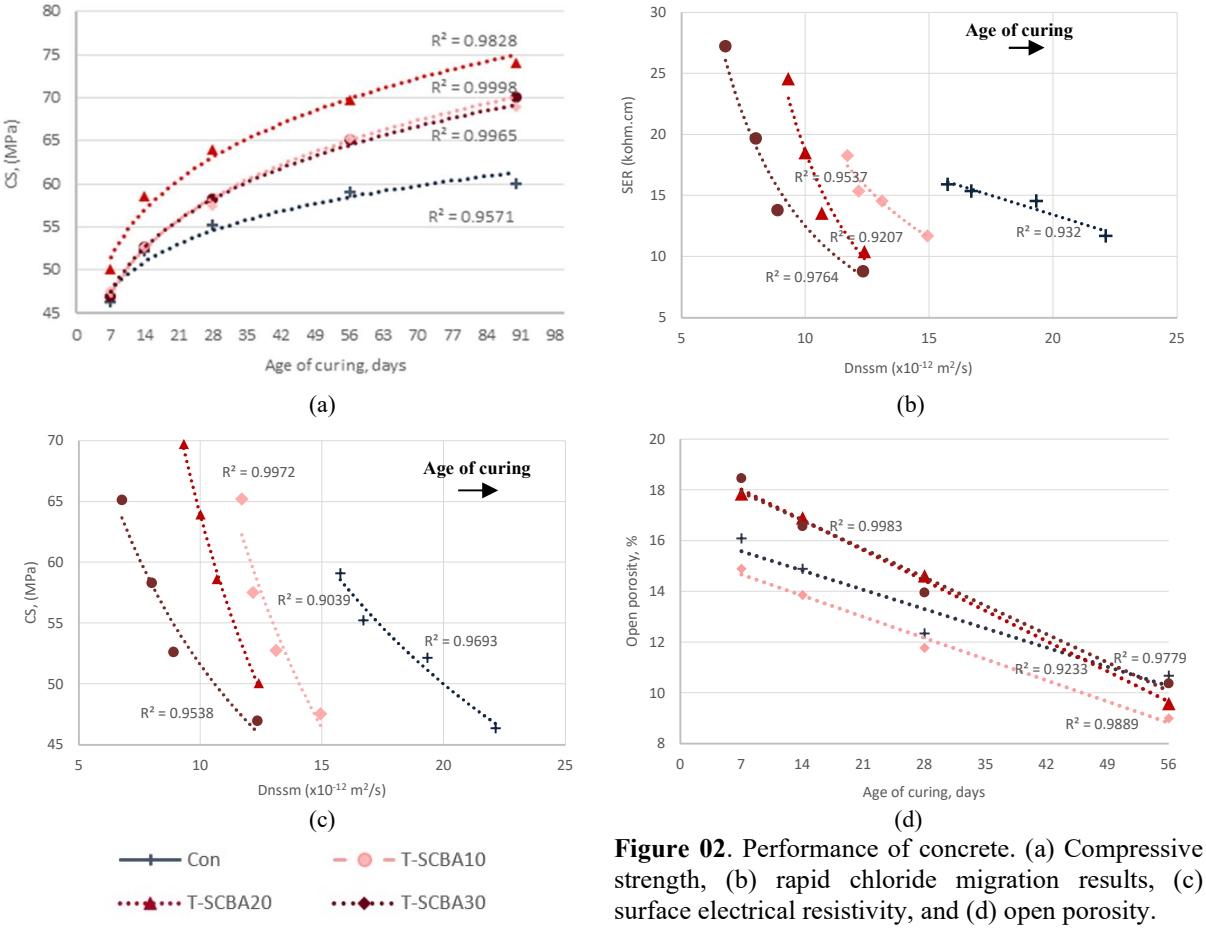

Figure 02. Performance of concrete. (a) Compressive strength, (b) rapid chloride migration results, (c) surface electrical resistivity, and (d) open porosity.

It is generally assumed that SCBA is more influential in terms of durability properties than compressive strength gain [8, 9]. However, in this research, the treatment applied boosted the mechanical strength gains in concretes at the same time it accelerated the process. Besides providing additional silica, the T-SCBA supplied more nucleation sites for the formation of secondary CSH and CASH gel [10] (confirmed by means of X-ray analysis). These gels refine and/or modify the capillary and pore structure densifying the matrix. However, despite of outperforming in CS and CPR, T-SCBA$_{20}$ and T-SCBA$_{30}$ specimens had higher initial open porosity up to 56 days in comparison to Control and T-SCBA$_{10}$ concretes. This means that the T-SCBA modifies the porosity structure (number, size, distribution, and tortuosity) of concrete in such a way that the CS and CPR increase at early ages, regardless the higher open porosity. By scanning electron microscopy (SEM) concrete specimens were visually inspected, figure 03. It was found that cracks were presented in the interfacial transition zone (ITZ) in the case of control specimens while in T-SCBA$_{20}$ were randomly distributed in the paste mainly. These observations could explain the previous statements, although further research is needed.

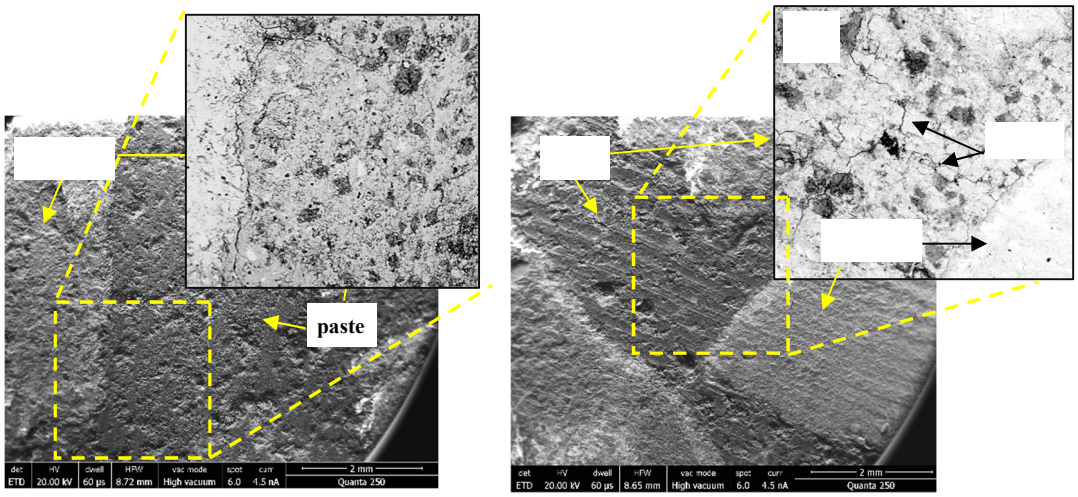

Figure 03. SEM of control (left) and T-SCBA$_{20}$ (right) concrete specimens at 56 days. Zoom-in visualised by means of backscattering imaging (a) and (b).

5. Conclusions

Ut-SCBA was treated by mechanical activation to counteract the drawbacks (high water demand and low workability, low compressive strength) observed previously when using it as fine aggregates replacement in concrete. The following was concluded:

- The breaking down of the porous particles reduces the water demand of Ut-SCBA and improves the workability, leading to less porous concretes.
- The treatment boosts and accelerates the strength gains due to the supply of more nucleation sites for the formation of more secondary CSH and CASH gel. At 14 days, the CS of T-SCBA$_{20}$ outperformed that of plain concrete at 28 days.
- The use of T-SCBA reduces the chloride penetration resistance up to 58.8% with values that Ut-SCBA (with lower workability) only achieves after 240 days. The CPR increases with increasing the amount of ashes used.

T-SCBA can be used as high-performance fine aggregate in the production of more durable and tougher concrete to extend the service life of structures. This research finds a solution for ashes that are not suitable for cement substitution, and leverages the total mass of material, without producing further discards.

Acknowledgements

The authors of this paper wish to acknowledge the support of LJMU for the fully funded PhD Scholarship to Veronica Torres de Sande and San Pedro Bioenergy for supplying the ashes.

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Research trends in using virtual reality for the analysis and treatment of lower-limb musculoskeletal injury of athletes – a literature review

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Abstract. A developing field applies virtual reality (VR) for rehabilitation, however, there is little research applying VR to the treatment of musculoskeletal injury in athletes. This is despite their prevalence and implications. This systematic review identified publications that used VR interventions for the analysis or treatment of lower-limb musculoskeletal injury of athletes. It established a search protocol, and through narrative discussion, identified existing trends. Database searches encompassed four term sets: 1) VR systems; 2) musculoskeletal injuries; 3) sporting population; 4) movement outcome analysis. Overall, of 126 publications twelve were included in the analysis and discussion. Many were pilot and proof of concept work, and seven of the twelve publications were observational studies. However, this may provide preliminary data from which clinical trials can branch. If specified, the focus was narrow, with similar population demographics and injuries. The trends emphasised the role of VR and attentional focus, the strategic manipulation of movement outcomes, and transfer of skill to the real-world. Causal inferences may have been undermined by flaws, as most studies were limited by the practicality of conducting a two-factor clinical-VR-based study. In conclusion, assessing exploratory studies would inform future work when developing a novel application that is established to utilise VR with dynamic movement for the effective treatment of specific musculoskeletal injuries of athletes.

Keywords. Athletes, lower-limb musculoskeletal injury, rehabilitation, return-to-sport, virtual reality.

1. Introduction

Fully immersive virtual reality environments (VREs), delivered through head-mounted displays (HMDs), are increasingly used in rehabilitation contexts [1]. Manipulating VREs formed of easily modified dynamic three-dimensional (3D) stimuli in rehabilitation contexts can be beneficial for several reasons, including allowing for full control over treatment and research scenarios [2]. Patients can perceive tasks that are representative of real-world functions [3], and greater ecological validity may have individuals display a closer approximation to potential real-life behaviour [4]. This could potentially offer generalisable predictions of functional performance [3]. Additionally, VR has been seen to assist rehabilitation by providing patients with appropriate feedback, reinforcing selected movements and improving motivation [4-7]. VR for rehabilitative purposes is a continually developing area of research, which is being applied in different rehabilitative fields.

Current research involving VR for rehabilitation is extremely varied [8-13]. However, little research applies VR to treating musculoskeletal injury.

As reviewed by Lin et al. [14], the use of VR for the treatment of musculoskeletal system disorders is still an emerging field. However, it could be argued that VR could be more successful in the treatment of musculoskeletal injury in more active populations that are used to rigorous rehabilitation practices, and that the treatment of non-chronic musculoskeletal conditions would be best treated with more dynamic movement to restore function.

The aim of this systematic review is to identify and examine studies that used VR interventions for the analysis or treatment of musculoskeletal injury of athletes. Directing future research could have tangible impacts on using VR in physiotherapy and strength and conditioning practices, to prevent, assess, and treat sporting injury.

2. Methods

The following databases were searched to collate published articles: The CINAHL (EBSCO), IEEE/IET, MEDLINE (EBSCO), Scopus, SPORTDiscus (EBSCO), and Web of Science.

The term sets included words for: 1) musculoskeletal injuries; 2) virtual reality environments; 3) analysis of movement outcomes; 4) sporting or athletic population.

The first stage of screening involved titles and abstracts being reviewed for population and intervention, as well as language, with the criteria identified in figure 1.

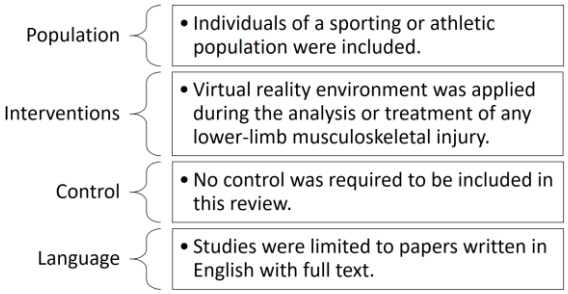

Figure 1. Screening inclusion and exclusion criteria.

During the second stage, the remaining full texts were then assessed for inclusion based on study outcome measures that quantified the effects of the intervention on human movement.

3. Results

Overall, a total of 126 publications were identified through database searching, and 12 were included in the final analysis and discussion. The selection process is detailed in figure 2.

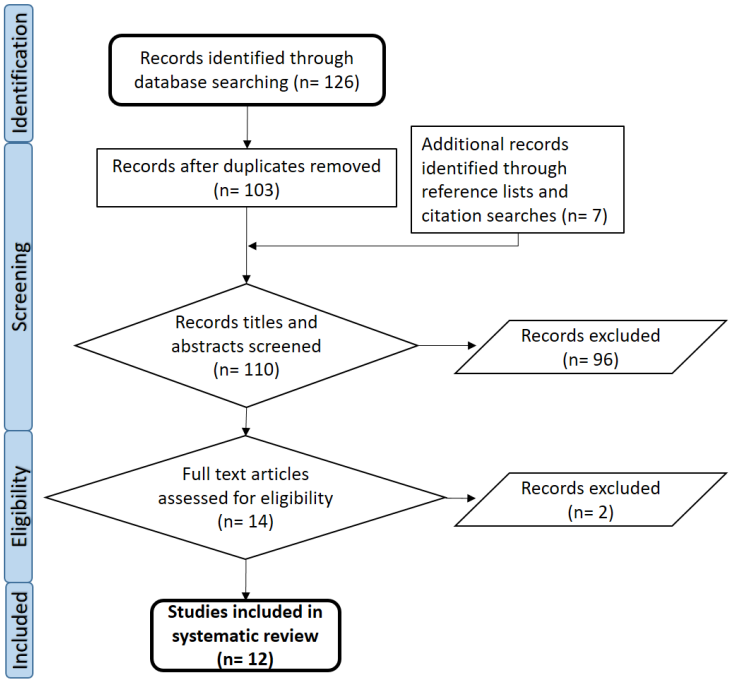

Figure 2. Selection process.

4. Discussion

4.1. Overview of the Literature

Twelve laboratory-based studies were identified as meeting the current eligibility criteria [15-26], as seen in figure 3, with publications predominantly being pilot work or proof of concept studies.

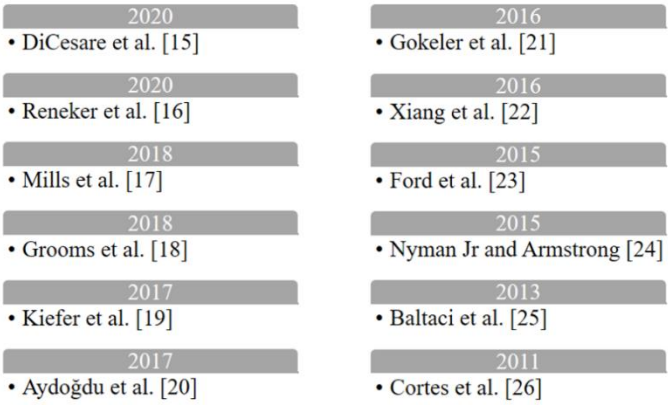

Figure 3. Studies included in literature review.

The studies could be categorized as having at least one of three main aims: 1) determine the effects of VR systems on neural mechanisms or movement patterns; 2) validate a VR system as an assessment tool for injury risk; 3) validate a VR system as a treatment tool for sustained injury.

If specified, studies mainly focused on anterior cruciate ligament (ACL) injury, or after ACL reconstruction (ACLR), obtained during football (soccer). The limited number of eligible publications and specific scope in population, indicates the use of VR in the context of treating musculoskeletal injury of athletes as an emerging field, and developments in this areas as novel.

4.2 Study designs of the Literature

Seven of the twelve publications were observational studies [15], [17], [18], [20-22], [26]. However, as many of the studies were pilot and proof of concept work, this observational research may provide preliminary data from which clinical trials will branch [27].

Fundamentally, there were trends in design and procedure, however, this depended greatly on the aim and the injury of focus. The studies were severely limited by the practicality of conducting a randomised control trial, with a two-factor clinical-VR based study, which could only be fully addressed in a risk of bias assessment.

4.3 Trends in Findings of the Literature

It was posited that VR could aid physiotherapy goals such as visual-perceptual processing, coordination, proprioception and functional mobility, similar to conventional treatment. The main trends are as identified:

- VREs are a means of accounting for laboratory environment and task presentation, improving ecological validity [26].
- Several studies attributed changes in movement outcomes to the fact that VR altered attentional focus [15],[17],[18],[21].
- A move from internally-focused biofeedback towards sport-specific meaningful tasks was identified [17], [19].
- Further to emulating non-VR biomechanics, actively developing VRE, with specific stimuli to elicit a specific response, was shown to alter outcome measures [15],[21].
- The transfer of rehabilitation training from VRE to the real-world is still a prevalent issue and an area of focus [16],[18].

5. Conclusion

The exploratory work discussed in this review provides different contributions to the ways in which VR could help treat sporting injuries. The studies emphasised the need for well-selected stimuli and feedback in the VRE. This research suggests VR could be applied to training and risk assessment to help reduce and prevent injuries seen during sport, as well as treat injuries sustained during sport. Overall, the trends in the literature findings emphasised the role of VR and attentional focus, the strategic manipulation of movement outcomes, and transfer of skill to the real-world. Many of the studies identified in the current literature review were pilot and proof of concept work. Additionally, the focus of the literature was narrow, with very similar population demographics and injuries. Furthermore, causal inferences may have been undermined by flaws, as most studies were limited by the practicality of conducting a two-factor clinical-VR-based study. Although this may be limiting, this does identify this field of research as novel. This may also provide preliminary data from which clinical trials will branch and which may emerge in the near future. In future research, assessing the existing work, highlighted in this review, and combining this with the use of numerous developments, techniques and tools, a novel application could be established. This application may look to integrate sport-specific VRE into existing rehabilitation practice, and could be designed to utilise VR with dynamic movement, for the effective treatment of specific musculoskeletal injuries of athletes.

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Assessing the Human Presence in the Artificial Intelligence Based Adaptive Comfort System to Lower the Energy Use

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Abstract. The design process for the heating system for the residential seldom involves the human presence and the adaptive aspect of the occupants. This paper aims to lower the energy while still achieving comfort. This approach assesses the human presence with the impact in increasing the percentage of comfort because of the heat emission from the human body. This assessment is based on the use of the artificial intelligence model. The model was developed based on the artificial neural network with ASHRAE RRP-884 and the ASHRAE Global Thermal Comfort Database II as the shallow learning dataset. This data set can represent the variation of human comfort. The learning result also shows a broader comfort zone than the standard comfort zone and the adaptive notion of human comfort. The result shows a more than 10% increase in the percentage of comfort with the human presence in the room. Further analysis also shows that the people's presence at night returns in higher comfort percentage compared with the afternoon presence. This result shows that human presence is also essential in the heating system design process.

Keywords. thermal comfort, human presence, adaptive system, artificial intelligence, artificial neural network

1. Introduction

1.1. Fuel Poverty and Energy Price Raise

Heating Ventilation and Air Conditioning (HVAC) are the primary energy used in households. Compared to the total energy consumption in the household, HVAC consumption can reach more than 64% [1]. In Europe, the household sector represents 27.2% of final energy consumption, while in the UK, the use of heating and hot water represents approximately 25% of total energy consumption for UK homes. Fuel poverty is defined as the inability to afford adequate heating energy at home [2]. Fuel poverty increase is the rise in energy prices and the dwelling age. Older homes require more energy to heat, resulting in higher fuel costs.

Only 17% of homes were built in the last 30 years in the UK [3]. The modern home uses building standards, techniques, and materials that aim to improve energy efficiency and, as a result, will have more minor heating requirements. The previous era of housing will differ in building standards, techniques, and materials which results in different heating requirements. As a comparison, pre-1919 homes can have 70% higher energy costs than their post-1990 equivalents [4]. Based on 2019 data for English homes, over 20% of total residential dwellings are pre-1919 houses, producing double carbon emissions [3]. The dwellings constructed around 1919-44 are about 16%, 1945-64 about 19% and 1965-80 are also about 20%.

Looking at the percentage of households living in fuel poverty across the UK, the value for England is 11%, Wales is 25%, Scotland is 23%, and Northern Ireland is about 21% [5, Welsh 6, Scottish 7, Northern Ireland Housing 8]. The data shows the importance of this work. Furthermore, the United Nations have set the Agenda for Sustainable Development adopted by all United Nations Member States in 2015. The focus is on the 17 Sustainable Development Goals (SDGs), which fight against poverty and other deprivations, tackle climate change and achieve sustainable cities and communities[9].

1.2. Adaptive Thermal Comfort

Thermal comfort is a state of mind that expresses contentment with one's immediate thermal environment. In 1970, Fanger established the ground-breaking model for thermal comfort [10]. This work is based on human physiology measurements taken in a climate chamber. The indoor environment can be simulated and controlled in this chamber. This model is built around the relationships between the influencing parameters (1). The method was then extended with the Predicted Mean Vote

(PMV)/Predicted Percentage of Dissatisfied (PPD). This method has become a standard reference work on thermal comfort, serving as the foundation for ISO 7730–2005 [11] and being recognised by the ASHRAE-55 Standard [12].

Nicol and Humphreys propose an adaptive method to solve the problem of having variations in subject preferences, particularly the person with special needs [13], which introduces human behaviour to the method. Adaptation can be physiological, related to the body's adaptation to temperature change, psychological, formed by previous human experiences, or behavioural [14]. If people are given room to adapt, comfort can be achieved [15]. This adaptive method has also been recognised by the ASHRAE-55 Standard [16].

The black box approach is frequently used to deploy adaptive thermal comfort models [17]. Unlike the thermal physiology model, the black box model does not include precise calculations of physical parameters. A more extended period is also required for complete thermal adaptation. Suppose the training data is collected directly from the occupants during system implementation. There will be insufficient data to cover the entire extreme condition, putting the user in an uncomfortable situation and raising the user's scepticism. Because comfort is a state of mind, it can harm the system [18]. Using the system which trains the adaptive model's AI subsystem with multiple ASHRAE physiology measurement Databases, the human behavioural factor can be acknowledged.

1.3. Comfort Zone, Exposure to Cold Weather and Health Effects

Because of its significant impact on health and safety, thermal comfort is critical in the design process of the indoor artificial climate. Thermal conditions also have an impact on productivity [19]. The PMV-PPD method [16] can be used to predict the comfort zone. The ASHRAE-55 Standard [12] includes the PMV-PPD comfort zone. Givoni [20] defines the comfort zone in addition to PMV-PDD. The PMV-PPD is prescriptive, based on the thermal chamber measurement. Because comfort is based on satisfactory human adaptation, there is potential to expand the comfort zone based on the adaptive approach.

A specific group of people, such as the young, elderly, disabled, or temporarily ill, may have a different comfort range than the PMV-PPD method. For example, the elderly population has higher comfort temperatures [21], [22]. On the other hand, a request for a lower comfort temperature may be made due to a health recommendation. Frequent cold exposure has been shown to help people lose body fat [23]. Increasing adaptive thermogenesis by activating brown adipose tissue (BAT) is a promising practical strategy for preventing obesity and related disorders. BAT is a thermogenic tissue in which heat is produced when the human body is exposed to a cold environment. The study recommends that the indoor environment introduces cold exposures to reduce the energy for heating and reduce the possibility of obesity.

Similar to this trial, Hanssen et al. also propose that ten days of cold acclimation period can increase BAT and improve the metabolic profile of skeletal muscle to benefit glucose uptake in patients with type 2 diabetes[24]. Davis's well-known cold acclimation protocol is the 31 days of cold air exposure in 1961 and two hours of daily cold exposure for four weeks by Blondin in 2017. Subjective responses to cold will improve with regular exposure to cold acclimation [24]. This may change the thermal preferences of the occupants over time. Previous research has also shown that lowering the temperature setpoint can reduce the carbon footprint while keeping indoor humidity within a healthy range [25].

In accommodating the possibility of lower temperature and a wider possibility of the comfort zone, the previous research proposed using artificial intelligence solutions to overcome the problem [26]. As a further investigation, this work aims to investigate the further impact of human presence inside the house on the comfort percentage.

2. Methods

The trial was based on the nine-week field study in the 1970s' BRE House, Liverpool John Moores University, Byrom Street Campus. The trials were divided into three groups: the trial with no people present, the trial with people between 09:30 and 18:00 and people from 21:30 to 06:00 Monday to Friday to represent the three house indoor conditions. The field study was done during the transition periods from winter to summer to capture the variation of the indoor condition. Due to health and safety reasons, the people models were developed based on the value from ASHRAE Standard 55 [16] to represent two people in the sleeping or resting condition or a single person in the light work state.

2.1. Artificial Neural Network Model

The model used shallow supervised learning to accommodate the broader need for a thermal comfort zone and was deployed as the artificial neural network system. The solution uses the ASHRAE databases RRP-884 and Global Thermal Comfort II databases based on thermal physiology measurements and respondent interviews. Human presence also can raise the indoor temperature due to the human body having the heat dissipated to the surrounding. The value is according to human activity [16].

2.2. Limitation and Scope

Thermal comfort and indoor thermal conditions involve the combination of complex parameters. Thermal comfort involves the age, gender, clothing, activity or metabolism rate, state of mind, previous exposure to climate (memory) and other complex parameters. The indoor thermal condition involves indoor temperature, relative humidity, dew point, solar radiation, indoor airflow, building envelope materials and insulation, thermal storage, and thermal leakages. It is also affected by the outdoor condition. It needs simplification to test the human presence in the residential places.

The simplification introduced in this research are:

- The data were collected in an unoccupied 1970s BRE House with the radiator off position.
- Outside temperature and humidity, inside room and the adjacent room (stairs) black globe temperature and humidity were taken in 15 minutes intervals using the network of sensors.
- Air velocity is measured with the precise hot-wire anemometer then simplified due to the low value of the air velocity reading.
- The AI system utilised the five most influential parameters, which are measured temperature and humidity, age of the person (using median age of people in the UK), clothes (using the recommended clothing value from ASHRAE), and activity (light work).

3. Result and Discussion

The result from three groups of the trial is tabulated to be able to be appropriately analysed and minimise the factors that have been simplified. In order to compare each group and minimise the error due to the simplification, the whole data on each group is compared with the corresponding data that have similar properties. Since the indoor temperature data is affected by the outdoor and the adjacent room (stairs) temperature, the data are grouped into entries with the same outdoor temperature data and adjacent room data. With this approach, the error due to parameter simplification can be minimised. The analysis of the measurement result can be seen in table 1.

The average indoor temperature where no people are present is 14.2 °C, whereas the indoor temperature where people are present in the afternoon is 14.25 °C. The result shows a slight increase where there were people inside the room. Similarly, when there are people at night, it can increase the average temperature value from 17.28 °C to 17.82 °C. The exciting result was also acquired when the people present were compared with afternoon and night presence. The average indoor temperature data for the afternoon presence was 16 °C compared to 16.73 °C for the night presence. This result shows that there were more borderline indoor temperature conditions at night compared to the afternoon. The people's presence will be affecting more on the indoor temperature conditions.

3.1. Percentage of Comfort

Table 1 also presents the percentage of comfort as the output of AI models that predict the percentage of comfort for each data item with corresponding temperature and humidity. This trial uses the median age of people in the UK, 40.5 years, clothes value of 1 clo, which is the recommended clothing value from ASHRAE for winter and activity value of 1.5 met, which is associated with light work. The percentage of comfort for the corresponding indoor condition where no people present is 5.07 compared to 24.77 where the people present in the afternoon. Similarly, when there were people at night, the percentage of comfort can increase from 71.83 to 82.04. If the people are present in the afternoon compared with the night, the percentage of comfort will rise from 51.97 to 79.93. This shows that the human presence at night has the most impact during winter's indoor conditions.

Table 1. Field Measurement Result Analysis

		Indoor Temp	Indoor RH	Stairs Temp	Stairs RH	Outdoor Temp	Outdoor RH		Indoor Temp	Indoor RH	Stairs Temp	Stairs RH	Outdoor Temp	Outdoor RH
Min	No People	13.10	44.11	13.00	46.47	4.00	60.00	Day Presence	11.54	41.14	13.00	44.83	4.00	49.00
Max		20.90	57.77	18.92	60.95	15.00	92.00		20.90	55.38	18.92	63.57	15.00	94.00
Avg		14.20	53.87	14.26	54.34	7.63	79.41		14.25	49.74	14.26	52.42	7.63	76.70
StdDev		1.03	2.04	0.90	2.33	1.62	6.83		1.65	3.05	0.90	3.79	1.62	11.95
Percentage of Comfort		**5.07**		4.88		0.84			**24.77**		4.88		0.84	
Min	No People	13.10	41.46	13.68	44.12	5.00	43.00	Night Presence	12.46	35.75	13.68	38.86	5.00	38.00
Max		20.98	57.81	20.60	60.17	20.00	92.00		20.90	53.83	20.60	65.30	20.00	93.00
Avg		17.28	48.60	17.43	50.03	10.47	75.73		17.82	40.68	17.43	44.62	10.47	65.15
StdDev		2.24	4.46	2.18	3.90	2.98	9.70		2.39	3.88	2.18	5.25	2.98	12.33
Percentage of Comfort		**71.83**		71.83		11.80			**82.04**		71.83		11.80	
Min	Day Presence	11.79	39.43	13.68	44.20	2.00	43.00	Night Presence	12.46	35.87	13.68	38.74	2.00	43.00
Max		20.91	54.88	19.50	63.49	16.00	94.00		20.32	53.58	19.50	63.33	16.00	92.00
Avg		16.00	46.40	15.90	49.58	8.72	75.86		16.73	43.20	15.90	46.82	8.72	73.12
StdDev		1.84	4.16	1.19	4.11	2.30	12.36		1.72	4.80	1.19	5.39	2.30	9.97
Percentage of Comfort		**51.97**		62.12		1.01			**79.93**		62.12		1.01	

3.2. Psychrometric Chart

The psychrometric chart for the comfort map result of the indoor condition with the people present in the afternoon is shown in figure 1a, and the people present in the night are presented in figure 1b. This chart shows the comfort condition in the middle part (green area), dominating the cold area (presented in blue). The cold area in figure 1a shows a broader area than 1b due to the more unsatisfied sensation being felt in this condition. On the other hand, the more comprehensive comfortable condition is shown in figure 1b representing more percentage of comfort shown for the human presence at night.

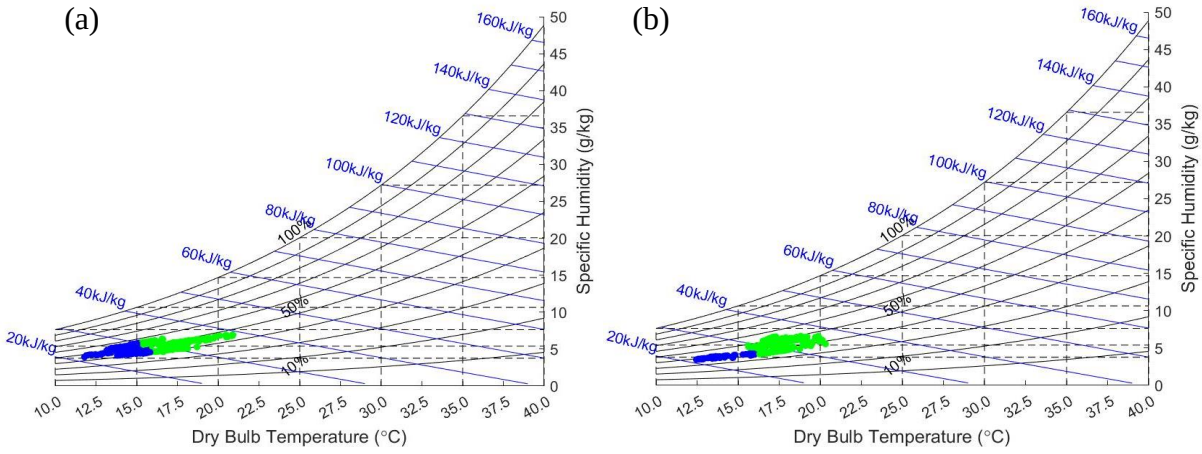

Figure 1. The Psychrometric chart for the comfort condition (a) with human presence in the afternoon (left) and (b) with the human presence at night (right).

4. Conclusions

This work shows that the data processed through the AI system demonstrate the following:

- The result shows a more expansive comfort zone than the standard comfort zone. This result shows the adaptive notion of human comfort.
- The comfort percentage increased to more than 10% with the human presence in the room. This proves that the human presence should be considered in the heating system design, particularly in the low border indoor temperature.
- Human presence at night results in higher comfort percentage compared with human presence in the afternoon. This result shows the importance of the scheduling being included in the heating control scheme.

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Design of aluminium alloy channel sections under minor axis bending

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Abstract. In recent years, numerous research works have been reported on the flexural response of aluminium alloy tubular cross-sections. However, studies on monosymmetric cross-sections and particularly channel (C-) sections are limited, albeit their increased usage in structural applications. This paper aims to address this knowledge gap providing an improved understanding about the minor axis bending behaviour of C-sections through an experimental and numerical investigation. In total 14 specimens made from 6082-T6 heat-treated aluminium alloy were subjected to four-point bending. Tensile coupon tests were also performed to determine the mechanical properties of the examined aluminium alloy. The obtained experimental results are analysed and discussed. A series of geometrically and materially nonlinear analyses were also carried out to study the flexural performance of C-sections in two aluminium alloys and two bending orientations over a range of cross-sectional aspect ratios and slendernesses. The experimental and numerical results are utilised to assess the European design standards. The applicability of the Continuous Strength Method and the Direct Strength Method is also evaluated. An alternative design method based on the plastic effective width concept is proposed for slender C-sections subjected to minor axis bending. This method accounts for the inelastic reserve capacity which is in accordance with the experimental and numerical observations.
Keywords. aluminium alloys, beam tests, channel sections, numerical modelling, design standards, plastic effective width

1. Introduction

Nowadays, aluminium alloys are increasingly employed as structural material in the construction industry. For example, aluminium alloys were used to support the glazing system of the Sage Gateshead building in Gateshead, United Kingdom and to form the modular façade elements of the Casablanca Finance City Tower in Casablanca, Morocco. 6,000 series aluminium alloys, known as structural alloys, are a great structural material choice, as they are able to satisfy strength requirements without increasing structure's self-weight. The fact that they reflect the ultraviolet radiation and are resistant against corrosion provides a longer service life and reduces the maintenance cost of the structure. These characteristics together with their high recyclability demonstrate their strong potential as a structural material.

Over the last 20 years, several experimental and numerical investigations [1-12] have been reported mainly focussing on the flexural response of aluminium alloy tubular and doubly-symmetric open cross-sections. However, research studies on monosymmetric aluminium alloy cross-sections and particularly channel (C-) sections are rather limited [13,14], despite their applicability in structures. C-sections as open sections are easy to connect during the assemblage and are often employed as rafters on light-duty roofs, studs in framed buildings, girts and pillars in curtain wall systems. This paper aims to address this knowledge gap providing an improved understanding about the minor axis bending behaviour of C-sections through an experimental and numerical investigation.

A comprehensive experimental programme was carried out to investigate the influence of the nonlinear material response on the flexural performance of aluminium alloy C-sections. In parallel, an extensive numerical parametric study was conducted to generate flexural performance data over a broad range of

key parameters. The obtained experimental and FE results are utilised to assess the European design standards [6]. The applicability of the Continuous Strength Method (CSM) [15] and the Direct Strength Method (DSM) [16] is also evaluated. An alternative design method based on the plastic effective width concept is proposed for slender C-sections subjected to minor axis bending.

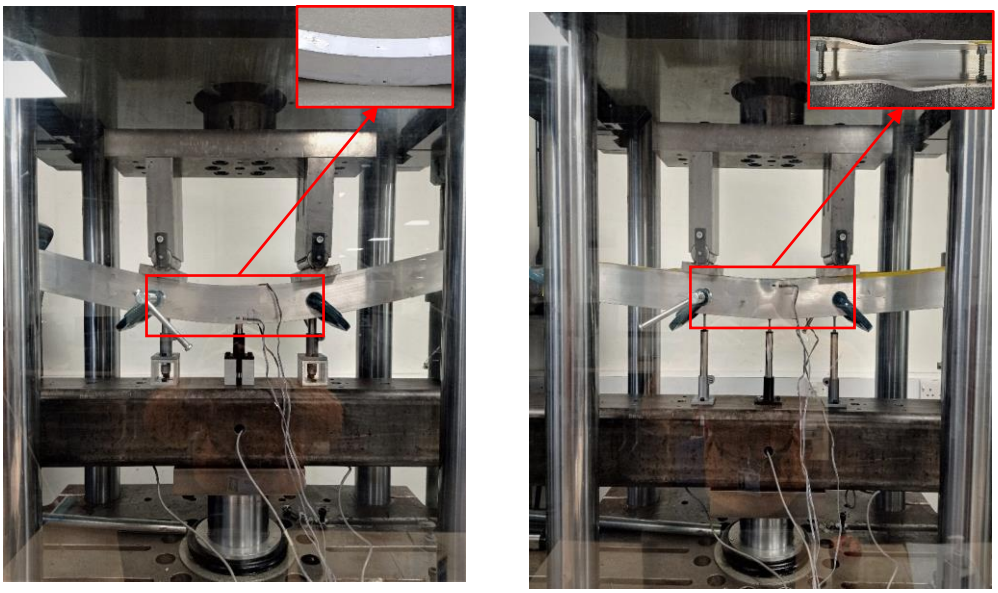
1. Experimental programme

The experimental investigation was performed in Light Structures and Materials Laboratory of the School of Civil Engineering and Built Environment at Liverpool John Moores University. A series of four-point bending tests was conducted to examine the flexural response of aluminium alloy C-section beams under minor-axis bending. Each specimen was tested in both the "n", i.e., maximum compressive stresses in web (see Figure 1(a)), and the "u", i.e., maximum compressive stresses in flange tips (see Figure 1(b)), bending orientations. The adopted testing methodology included the following four steps: i) Tensile tests on 6082-T6 aluminium alloy coupons ii) Measurements of the geometric properties of the specimens ii) Measurements of the initial local and global geometric imperfections of the specimens using a linear height gauge machine iii) Execution of four-point bending tests.

(a) "n" bending orientation (b) "u" bending orientation

Figure 1: Employed bending orientations.

Material yielding (Figure 2(a)) and local buckling (Figure 2(b)) were the governing failure modes for beam specimens under "n" and "u" bending orientation, respectively. The results, also, demonstrated the fact that a C-section is more susceptible to local buckling when the maximum compressive stresses are induced in the flange tips, i.e., "u" orientation, rather than in the web, i.e., "n" orientation.



(a) Material yielding (b) Local buckling in the flanges

Figure 2: Typical failure modes obtained from four-point bending tests.

2. Finite element modelling study

A parallel numerical study was carried out in the commercial software package ABAQUS to extend the pool of flexural performance data for aluminium alloy C-sections. The adopted finite element modelling methodology included the following five steps: i) Development of the finite element models (see Figure 3) ii) Validation of the finite element models against the test results iii) Execution of parametric studies

in order to examine the effect of key parameters on the flexural performance. Particularly, a wide range of cross-sectional aspect ratios and slendernesses was considered, as well as two aluminium alloys (i.e., 6082-T6 and 6063-T5, a typical high and normal strength heat-treated aluminium alloy, respectively).

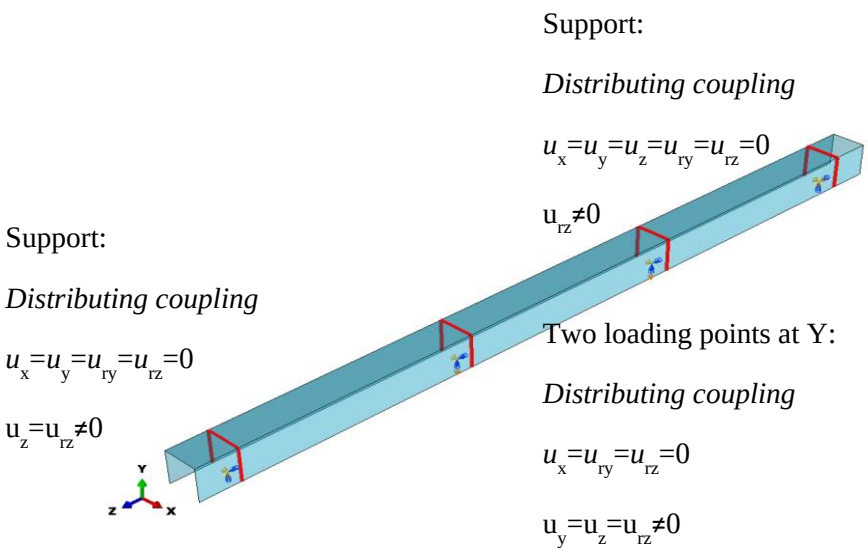


Figure 3: Modelled geometry of a typical beam specimen and the corresponding applied boundary conditions.

3. Assessment of international design codes and design methods

The ultimate bending moment capacities obtained from the experiments and parametric studies are utilised to evaluate the applicability and accuracy of the design rules specified in Eurocode 9 (EC9) [6]. Three design approaches are also assessed; the CSM [20], the DSM [21] and the plastic effective width method [17].

4. Conclusions

The present research study experimentally and numerically investigated the flexural response of C-sections about the minor axis. Particularly, the examined C-sections were subjected to four-point bending under both “n” and “u” orientations inducing compressive stresses in the web and flange tips, respectively. The following conclusions can be drawn from this research study:

- Regarding C-sections under “n” bending orientation, EC9 provides conservative design strength predictions for stocky cross-sections and the level of conservatism further increases for slender cross-sections. Evaluation of the DSM revealed that it consistently underestimates the ultimate bending moment capacities by 53%. Conversely, CSM appears to offer quite improved results for stocky cross-sections, although it is overly conservative for slender cross-sections.
- Regarding C-sections under “u” bending orientation, EC9 underestimates by 36% the ultimate bending moment capacities. CSM was found to provide the most accurate design strength predictions for stocky cross-sections. DSM is rather conservative for stocky cross-sections, although it offers quite accurate design strength predictions for slender cross-sections.
- Regarding slender C-sections in both orientations, it was demonstrated that the outstand elements exhibit inelastic strain distribution prior to the attainment of the elastic bending moment capacity, which is line with past observations for steel sections. The applicability of the plastic effective width method to aluminium alloy C-sections was evaluated, leading to quite accurate and consistent design strength predictions. Modified design equations were proposed for “u” bending orientation which further improved the accuracy and consistency of the original design formulae by 11% and 50%, respectively. Overall, it is recommended that the plastic effective width method can be employed for the design of slender aluminium alloy C-sections subjected to minor axis bending.

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