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Optimization of School Platform through Multi criterion Decision Making Tool

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Abstract:

Wooden platforms are indispensable across industries due to their versatility, durability, and visual appeal. This abstract outlines prevalent applications, objectives, methodologies, and an optimal solution derived from the investigation. The widespread use of wooden platforms stems from their adaptability to diverse environments and tasks. This work identifies gaps in existing literature to define key objectives for enhancing ramp design. By employing various techniques, the influence of different parameters on platform design is thoroughly explored through a series of 16 experiments. Utilizing OEC, a prominent Multi-Criteria Decision Making (MCDM) tool, the optimization of results obtained from ANSYS enhances the platform's performance. After analysis, the optimal solution is determined to be a 15 mm thick platform supported by three pillars. This abstract encapsulates the significance of wooden platforms, highlights research objectives, delineates methodologies employed, and presents an optimized solution, setting the stage for further exploration and application in diverse industrial contexts.

Introduction:

Wooden platforms are versatile, durable, and visually appealing, making them invaluable across multiple industries and settings. Let's delve deeper into some common applications In construction and building projects, wooden platforms serve as scaffolding, flooring, or staging, providing stable surfaces for workers at heights and facilitating safety and efficiency. Additionally, they can be utilized as temporary flooring during construction or renovation tasks. Event planning and production often employ wooden platforms as stages for performances, speeches, or presentations. These platforms offer sturdy, elevated surfaces for engaging with audiences and can be tailored in size and design to suit specific event requirements. Outdoor settings such as parks, gardens, and waterfronts benefit from wooden platforms as viewing points, picnic areas, or gathering spaces. Their integration enhances the natural environment while providing visitors with comfortable, elevated vantage points to enjoy surroundings.

In retail environments, wooden platforms are instrumental for product displays, adding visual interest and organization to store layouts. They effectively draw attention to featured products or promotions and are frequently utilized in trade shows and exhibitions for showcasing merchandise. Within warehouses, garages, or workshops, wooden platforms serve as elevated storage platforms or shelving units, optimizing storage capacity and organization. Customization options allow for tailored solutions to accommodate diverse storage needs. Home improvement projects often incorporate wooden platforms for constructing decks, patios, or raised garden beds, enhancing outdoor living spaces. They also enable the creation of elevated seating areas, outdoor kitchens, or play structures, offering homeowners versatile and customizable solutions. The utility of wooden platforms extends to school environments, where they support diverse activities and applications, providing practical, versatile, and aesthetically pleasing solutions for construction, events, outdoor spaces, and storage needs.

Literature review from previous research:

Many research works has been done in the field of design consideration of ramp. Following is the literature review of some papers giving more information about it.

Kiper, G. et.al [1] presented the design, prototyping, and testing process of a rollable ramp. The rollable ramps has benn provided a crucial accessibility aids with temporary or permanent solutions for individuals with mobility challenges. The work provide information about development of a rollable ramp design that balances portability, durability, and usability while meeting safety and accessibility standards. Donghun Lee et.al [2] investigated the effects of ramp slope, ramp height, and users' pushing force on performance, muscular activity, and subjective ratings during wheelchair driving on a ramp. Wheelchair accessibility found essential for individuals with mobility impairments. The factors influencing ramp usage has found crucial for optimizing accessibility design. Sunghyuk Kwon et.al [3] explored the impact of ramp slope, ramp height, and users' pushing force on wheelchair driving performance, muscular activity, and subjective ratings. Wheelchair accessibility has found vital for individuals with mobility impairments, and understanding how ramp design and user effort influence driving dynamics has been crucial for optimizing accessibility and user experience. Min K. Chung et.al [4] examined the influence of ramp slope, ramp height, and users pushing force on wheelchair driving performance, muscular activity, and subjective driving performance, muscular activity, and subjective ratings. Wheelchair accessibility has been found paramount for individuals with mobility challenges, and optimizing ramp design and user effort can significantly enhance driving dynamics and user experience. Michael F. Ashby, Campbell et.al [5] delved into the critical process of material selection in mechanical design, emphasizing the role of materials in determining the performance, reliability, and cost-effectiveness of engineered products. Material selection has been a fundamental aspect of mechanical design, influencing factors such as strength, stiffness, durability, and environmental impact. This work explored the key considerations and methodologies for selecting materials in mechanical design, drawing insights.

Research Methodology:

In previous chapter literature review, researcher methods and contribution is discussed and at the end conclusion from literature review is discussed. The objectives for the present work is decided. The research methodology for the robust design of a portable wheelchair ramp should be systematic and comprehensive, encompassing various phases from initial research to final validation. Here's a detailed methodology.

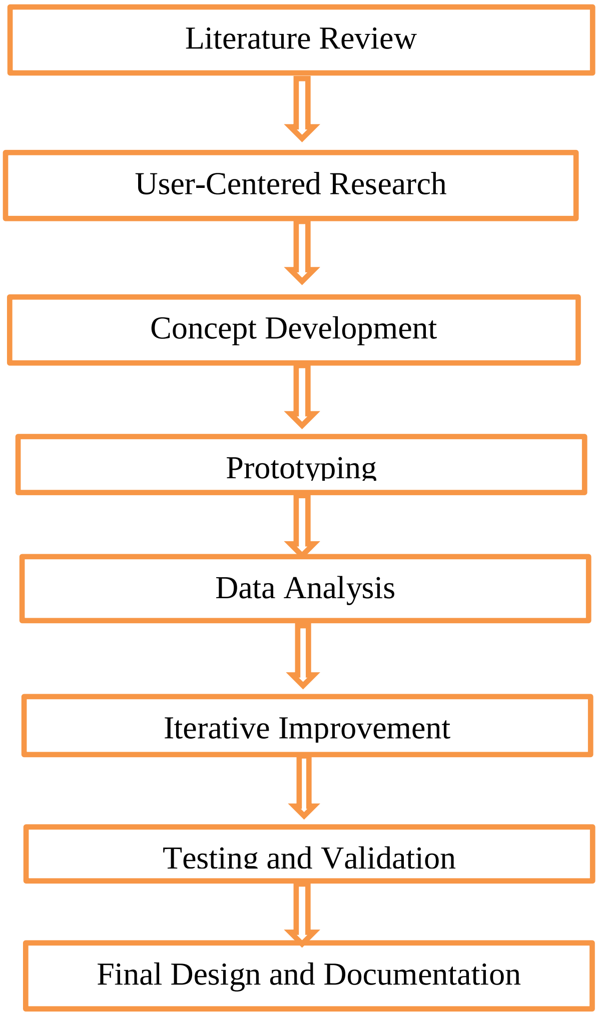

Fig. Number

Literature Review:

The main objective of Literature Review is to gather existing knowledge and identify gaps in current wheelchair ramp designs.

User-Centered Research:

The main objective of User-Centered Research is to understand the needs and preferences of end-users.

Concept Development:

The main objective of Concept development is to generate and evaluate multiple design concepts

Prototyping:

The main objective of prototyping is to create physical prototypes for testing and evaluation

Testing and Validation:

The main objective of Testing and validation is to rigorously test the prototypes under various conditions to ensure robustness

Data Analysis:

The main objective of data analysis is to analyze the data collected from testing and user feedback.

Iterative Improvement:

The main objective of iterative improvement is to refine the design based on testing and analysis.

Final Design and Documentation:

The main objective of final design and documentation is to finalize the design and prepare comprehensive documentation

This research methodology ensures a thorough and systematic approach to designing a robust portable wheelchair ramp. By integrating user feedback, rigorous testing, and iterative improvements, the final product will be both functional and reliable, meeting the diverse needs of its users.

Experimental Work:

For study the effect of various parameter on the design of ramp, different techniques has been used. These methods are explain in next point design of experiment. DOE capability helps to improve processes. It can screen the factors to determine which are important for explaining process variation. After screening the factors, appropriate tools help to understand how the factors interact and drive the design process. It can then find the factor settings that produce optimal design.

Design of Experiment:

Carefully planned experiments yield considerably more information and frequently demand fewer iterations compared to unplanned ones. Moreover, a meticulously designed experiment guarantees thorough evaluation of the identified important effects. There are four main types of which are explained in short as follows:

Factors:

In this experimentation, the factors are segregated in two categories, controllable and uncontrollable. The controllable factors are thickness of material and number of central supports. Again the thickness of material is varied from 12 mm thick to 25 mm thick. The number of central supports are again four values like no internal supports and three internal supports. Accordingly, set the levels of the controllable variables:

Thickness of Material : [25, 19, 15, 12];
Number of Central Support : [0, 1, 2, 3]

Response Parameters

Table Number 1

Ex. No.	Material thickness	Number of support
1	25	0
2	25	1
3	25	2
4	25	3
5	19	0
6	19	1
7	19	2
8	19	3
9	15	0
10	15	1
11	15	2
12	15	3
13	12	0
14	12	1
15	12	2
16	12	3

The two controllable factors with four internal levels constitute total 16 experiments. As this number is within range, full factorial experimentation is selected. The models are developed in CAD and the output in the form of response parameters are recorded. The response parameters are as below.

- Maximum Principal Stress
- Von-Misses or Equivalent Principal Stress
- Maximum Deformation
- Average Deformation
- Cost

The response parameters for all the experiments are recorded in the following table number 2

Experimental Reading

Table Number 2

Ex.no.	Max. Principle stress n/m2	Equivalent principle stress (Mpa)	Max. Deflection in mm	Avg. Deformation in mm	Cost in Rs.
1	32.55	3493.5	1.82138	0.07293	2959
2	28.49	3082.5	1.72788	0.06545	2959
3	24.55	2589.3	1.71292	0.05797	3014
4	20.35	2178.3	1.71666	0.0374	3083
5	31.88	3425	1.63438	0.05423	3357
6	28.34	3041.4	1.54088	0.04675	3357
7	24.8	2630.4	1.15192	0.03927	3425
8	21.34	2315.3	0.78166	0.0187	3494
9	30.03	27.45	1.4473052	0.0361882	4494
10	26.67	2712.6	1.33518	0.02805	4494
11	23.22	24.39	1.14818	0.02057	4590
12	20.01	23.02	0.77418	0.00935	4658
13	28.15	3041.4	1.26038	0.1683	5891
14	26.5	2877	0.96118	0.1496	5891
15	21.25	2438.6	0.58718	0.1309	5960
16	17.5	1822.1	0.40018	0.0561	6028

Optimization:-

Optimization involves finding the best solution to a problem among a set of possible solutions. In various fields like engineering, economics, computer science, and more, optimization is used to maximize or minimize an objective function while satisfying certain constraints. The objective function represents what you want to maximize or minimize (e.g., profit, efficiency, cost), and the constraints are the limitations or conditions. In this case, for optimization, five factors are available, maximum principal stress in N/ m^2, Equivalent principle stress in Mpa, Max. Deflection in mm, Avg. Deformation in mm and Cost in rupees. In this case, the values of all the response parameters should be minimum. So optimization is required.

MCDM is a field that deals with making decisions when there are multiple conflicting criteria to consider. In many real-world scenarios, decisions need to be made considering multiple objectives, which often conflict with each other. MCDM provides methods and techniques to analyse, evaluate, and rank alternatives based on these multiple criteria. Firstly we will try to optimize this with the help of Overall Evaluation Criteria. (OEC). The weightage factors decided are as follows

Table Number 3 Weightage

Sr. No	MPS	Deformation	Cost
OEC 1	33	33	34
OEC2	25	25	50
OEC3	25	50	25
OEC4	50	25	25

Imperial Case Study:

In this paper now let us discuss an imperial case study of OEC1. The importance of imperial case studies lies in their ability to provide depth, nuance, and context to our understanding of imperialism and its legacies. By focusing on specific cases, researchers can uncover hidden histories, challenge dominant narratives, and ultimately contribute to a more comprehensive understanding of the complexities of imperialism.

The weightages for the first overall evaluation criteria is 33% weightage is for the Maximum principal stress, 33% weightage is for Maximum deformation and 34 % weightage is for the remaining factor i.e. cost. The values of Equivalent principle stress and Average deformation is found to be moving parallel to maximum principal stress and Maximum deformation respectively. Now calculating the values for the all the response factor like maximum principal stress, equivalent principal stress and cost are tabulated in the following table number 4

Table for OEC 1:

Table Number 4

Max. Principal Stress N/Mm2	Max. Deflection	Cost	Final Oec
0	0	34	34
8.92	0	34	42.92
17.56	0.09	33.39	51.04
26.75	0	32.63	59.38
1.48	0	29.6	31.08
9.24	0	29.6	38.84
17	9.31	28.84	55.15
24.59	20.98	28.08	73.65
5.54	0	17	22.54
12.9	0	17	29.9
20.47	4.3	15.94	40.71
27.5	18.65	15.18	61.33
9.65	0	1.52	11.17
13.27	32.46	1.52	47.25
24.78	32.89	0.76	58.42
33	33	0	66

From this table, it is concluded that, Experiment Number 8 (i.e. 15 mm thick with 3 supports) is the best solution for this weight of overall evaluation criteria. The same procedure is carried out for the next three criteria and the results are tabulated in the table Number 5

Optimization:

Table Number 5

ExNo	Max. Principle stress N/m2	Equivalent principle stress (Mpa)	Max. Defle-ction	Avg. Deformation	Cost	OEC1	OEC2	OEC3	OEC4
1	32.55	3493.5	1.82	0.07	2959	34	50	25	40
2	28.49	3082.5	1.73	0.07	2959	42.92	56.75	31.75	48.11
3	24.55	2589.3	1.71	0.06	3014	51.04	62.48	38	55.33
4	20.35	2178.3	1.72	0.04	3083	59.38	68.25	44.26	62.71
5	31.88	3425	1.63	0.05	3357	31.08	44.65	22.89	36.17
6	28.34	3041.4	1.54	0.05	3357	38.84	50.53	28.77	43.22
7	24.8	2630.4	1.15	0.04	3425	55.15	62.34	48.19	57.85
8	21.34	2315.3	0.78	0.02	3494	**73.65**	**75.81**	71.06	**74.46**
9	30.03	27.45	1.45	0.04	4494	22.54	29.2	16.7	25.04
10	26.67	2712.6	1.34	0.03	4494	29.9	34.77	22.27	31.72
11	23.22	24.39	1.15	0.02	4590	40.71	42.21	33.75	41.27
12	20.01	23.02	0.77	0.01	4658	61.33	57.29	60.26	59.81
13	28.15	3041.4	1.26	0.17	5891	11.17	9.55	8.43	10.56
14	26.5	2877	0.96	0.15	5891	47.25	36.88	60.36	43.36
15	21.25	2438.6	0.59	0.13	2959	58.42	44.8	69.16	53.32
16	17.5	1822.1	0.4	0.06	2959	66	50	**75**	60

Conclusion:

To explore the impact of controllable variables such as material thickness and the number of central supports, CAD is employed for modelling purposes. Design of Experiments (DOE) is then utilized to determine the requisite number of experiments based on these controllable variables and their respective factors. A total of 16 experiments are meticulously designed and analysed to ascertain the response parameters. For optimization, Overall Evaluation Criteria, a prominent tool in Multiple Criteria Decision Making (MCDM), is applied. The optimized parameters are elucidated through an in-depth imperial case study.

From this table number 5 it is found that, for OEC 1, 2 and 4, experiment number 8 (i.e. 15 mm thick with 3 supports) is the best solution. For OEC 3, as the more weightage is given to deformation and less weightage is given to cost, experiment number 16 is found best solution, but selecting the second best solution, finally one can conclude that Experiment Number 8 (i.e. 15 mm thick with 3 supports) is the better solution.

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