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DESIGN AND FABRICATION OF EMERGENCY FIRE RESCUE MACHINE

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Abstract -Building fires pose a serious risk to people, property and the environment. Numerous factors, such as human mistakes, electrical issues, heating systems, combustible items, might cause fire accidents. The effects of fire can be disastrous, resulting in accidents, fatalities, and significant building damage. Compared to fires in low-rise structures, high-rise building fire incidents pose numerous difficulties and a greater risk. High-rise building's vertical structures, greater resident capacity, and intricate infrastructure make fire fighters and evacuating residents more difficult to escape. It is essential to comprehend the causes, effects, and preventive strategies unique to high-rise fires in order to ensure occupant safety and reduce property damage. The disturbingly high rate of fire events, which are frequently brought on by inadequate fire prevention measures and damaged infrastructure, represent a serious threat to people's lives, their property, and the health of the economy. India can reduce the dangers connected with fire incidents in high-rise structures and guarantee the safety and well-being of its residents in the urban environment by giving priority to the implementation of appropriate rescue systems. So in this project we are going to develop such machine which can help humans to get escape in the case of emergency situation in high rise buildings.

***Key Words*:** Fire accidents, Existing techniques, Emergency Fire Rescue Machine , Governor Mechanism

1.INTRODUCTION *(Size 11, Times New roman)*

Safe escape in a high-rise building fire disaster is a worldwide insurmountable difficulty due to the intricate architecture of the building and the enormous number of people. Fires can destroy property and kill a large number of people. Those with mental, physical, and sensory impairments are at a higher risk of being hurt in a fire or becoming a fire victim. Over the past few decades, the development of high-rise structures has increased in India, a country that is fast developing and has a thriving urban environment. These modern marvels of architecture represent advancement and progress, but they also present serious fire safety challenges. High-rise building fires have grown to be a serious problem, with disastrous effects on property, persons, and the environment. The purpose of this introduction is to raise awareness of the alarmingly high frequency of fire occurrences in India's high-rise structures and the urgent need for all-encompassing fire safety measures. Rapid urbanization, population expansion, and the need to effectively use the country's limited land resources are all factors that have contributed to the spread of high-rise buildings in India. Cities with high buildings housing office buildings, apartment buildings, and commercial businesses include Mumbai, Delhi, Bangalore, and Chennai. However, due to a number of issues, such as crowding, a lack of infrastructure, poor construction methods, and a lax enforcement of fire safety regulations, the vertical expansion has also increased the likelihood of fire mishaps Numerous high-profile fire incidents in India's tall buildings have brought attention to the urgent need for prompt action. For instance, a fire at the Kamala Mills facility in Mumbai in 2017 that killed 14 people and revealed fire safety rules' flaws. Similar to this, a 32-year-old male was brought dead after the broke out in Andheri west area on Friday 29th July 2022 evening and prompted questions about how well-prepared such structures are to handle crises [2,4,5]. The Government of India and local authorities have started reviewing fire safety standards and regulations in order to address the growing concerns regarding fire accidents in high-rise structures. The stringent implementation of current regulations, including upkeep of fire-resistant building materials, installation of sufficient fire detection and suppression equipment, regular fire drills, and improvement of firefighting crew skill, is being pursued. Through educational initiatives and public involvement, the emphasis is also on raising awareness among building occupants and fostering a culture of fire safety [6]. So there is an urgent need to address fire safety issues given the expansion of high- rise buildings in India. The alarmingly high rate of fire incidents in these buildings, which frequently result from ineffective fire prevention measures and damaged infrastructure, poses a serious risk to lives, property, and the stability of the economy. India can reduce the risks associated with fire accidents in high-rise buildings and guarantee the safety and well-being of its citizens in the urban environment of the future by giving priority to the implementation of strict fire safety

regulations, improving building design, and fostering awareness among stakeholders.

History: In modern times people take technology for granted. In pretty much every profession, from the medical field to architects and from teachers to lawyers, vast technological advancements are constant. Technologically speaking, these fields are constantly changing throughout the decades. The same goes for firefighting. There have been recent advancements in firefighting like the addition of jet packs, thermal imaging, and exoskeletons. It makes you wonder what the early days were like. It makes you wonder how difficult it must have been to fight fires centuries ago.The first roman fire brigade was created under Marcus Licinius Crassus. He preyed upon Rome having no fire department. His fire brigade would arrive at the scene of a fire and Crassus would negotiate the price of their services. If he did not receive a satisfactory offer, he would let the building burn to the ground. Afterwards, he would offer to buy what was left for a highly discounted price. This shows how lacking firefighting technology was back then, and how far we have advanced technologically to this day.In 1721 a british inventor by the name of Richard Newsham patented the first fireengine pump. It was on a wheeled cart and required a few men to work the cross handles. It shot at fire up to 135 feet.Also the fire extinguisher we know today was patented in 1863

Existing technologies used in fire accidents:

A.Fire extinguisher

A fire extinguisher is an active fire protection equipment that is typically used in an emergency to contain minor flames. It is not meant for use on an outof-control fire, such as one that has reached the ceiling, endangers the user (i.e., no escape path, smoke, explosion threat, etc.), or otherwise necessitates the use of a fire department's equipment, staff resources, and/or experience. A fire extinguisher is a portable active fire-fighting equipment that is generally packed with a dry or wet chemical and is used to extinguish or control minor fires, frequently in an emergency. It is not meant for use on an out-of-control fire, such as one that has reached the ceiling, endangers the user (i.e., no escape path, smoke, explosion hazard, etc.), or otherwise necessitates the use of a fire department's equipment, staff, resources, and/or experience. A fire extinguisher is typically made out of a hand-held cylindrical pressure vessel carrying a chemical that may be released to extinguish a fire. Fire extinguishers made with non-cylindrical pressure vessels are also available, but they are less frequent.

B. Fire sprinkler system

A fire sprinkler system is an active fire prevention technology that consists of a water supply system that provides enough pressure and flowrate to a water distribution pipe system that is connected to fire sprinklers. Although formerly employed mainly in factories and big commercial buildings, systems for homes and small buildings are now affordable. Fire sprinkler systems are widely utilised across the world, with over 40 million sprinkler heads installed each year. Fire sprinkler systems are primarily intended to save lives, although they are not always intended to protect the building. If a fire started in a structure that was totally protected by fire sprinkler systems, it was contained by the sprinklers alone in 96% of the cases.

C. Sky Saver:

Skysaver rescue kit is designed as a backpack which contains an integrated harness and a fire-resistant steel cable for easy and safe evacuation of individuals from high buildings. Sky Saver is an innovative provider of portable emergency evacuation kits utilizing its patented, high quality Controlled Descend Device (CDD) technology for emergency evacuations in industrial and home settings.

#Need of project:

Emergency can happen with anyone and situations became very critical if there is a fire incident, Time is very critical in a fire incident and delay in providing safe escape can lead to loss of life.

 Fire tenders faces many challenges in reaching the spot on time saving peoples one by one. The situation much more critical if the incident happens in a residential building, where there could be hundreds lives at risk during fire.

 Peace of Mind: Having Skysaver available in high-rise buildings can provide tenants with peace of mind by providing an alternative option for escape in the event of an emergency. It can reduce anxiety and boost trust in building safety procedures.

 Versatility Skysaver is portable and can be used in a variety of settings, including residences, office complexes, hotels, and other high-rise structures. Its adaptability makes it a valuable tool for emergency preparedness across different environments.

#Problem Statement:

Design and Fabrication of Emergency Fire Rescue Machine which is the foremost emerging technology to save human life for 4 floor building.

#Objectives:

- To design and develop a Emergency Fire Rescue Machine.

- Selection of Brake, Governor and Transmission system.

- To perform structural analysis and validate all components using FEA tool.

- Experimental validation of developed model.

We are going to develop a pure mechanical system in which we are using mechanical components like brake governor bearing etc. So it is important to select or design the proper mechanical component which will be best suitable to fulfil the requirement of emergency fire rescue machine to get the best results. After the designing of different components, we will carry out the Finite Element Analysis wherein we will follow the sequential three steps i.e. pre-processing, post processing and final solution and analysed how a design reacts under real world conditions and will compare the results with theoretical values. After the successful manufacturing of Emergency fire rescue machine, we are going to carry out multiple testing of the machine wherein we are going to mount the machine on the wall or slab and check it's effective operation for four floor building. We are going to compare the theoretical and actual values of time taking by the person for there safe landing, also we are going to visual inspect and set the brake mechanism and governor mechanism for it's Synchronous operation.

#Scope:

All the existing models are single use only which is a very big disadvantage and we will require multi use device which can be used to save more lives. The available rescue devices are very costly so very few families in India can afford to have life saving device for emergency situation. Existing devices needs to carried by user while going down and have chances of injuring the person using them. The existing technology called skysaver though it is multi use we need to go at the skysaver test centre lab to rewound it and it is required to recertified by skysaver so when the fire accidents will happen at that incident we can use the skysaver only for one time so we will require the number of devices same as the no of person waiting for rescue which is next to impossible so we are focusing to make the emergency fire rescue machine which can be reused multiple times. As mentioned in above paragraph we will require number of devices so it is very costly and also space consuming and also for the solo equipment cost is more than 75000/- So our focus is to make cost effective Emergency fire rescue machine. The skysaver device which weighs near around 15-20 Kg is supposed to be carried by the person using the device. In such a risky and rush scenario one can find it difficult to carry such a heavy device with him during fire accidents ,So we are going to develop a Emergency fire rescue machine wherein the person is not bound with any kind of weight with him. In emergency fire rescue machine the assembly is mounted on the wall or slab and the person only need to tough in the hook onto the jacket weared by the person and simply get down from respective floor very safely and easily.

#Literature Review:

Tian, J., Zhou, J., Wang, H., & Meng, G, Literature Review of Research on the Technology of Wire Rope Non-destructive Inspection in China and Abroad,2015. This paper summarizes the existing methods of analysis at home and abroad from the perspective of strong magnetic and weakly magnetic; introduces the main methods of wire rope at the present, including principle and current status. At last, several critical problems in nondestructive testing of wire rope are discussed [11]. Holl, GW & Fairon, E., A Review of some aspects of shaft design,2010. The reasons for selecting vertical shafts over inclined shafts of equivalent capacity are explained, and the conclusion that the former are preferable in almost all instances is supported. The forms of vertical shafts dug throughout the last sixty years have been recorded, as have the shapes of those sunk recently. The last decade is examined. According to this research, circular and elliptical (and quasi-elliptical) shafts are the shafts of the future, while rectangular shafts may become obsolete [12]. Asim Rashid, Overview of Disc Brakes and Related Phenomena – a review, 2014. Disc brake is a complex system and understanding different issues related to its design and operation require expertise from different disciplines e.g. tribology, material science, fluid dynamics, vibrations etc. Disc brakes have evolved a lot over the decades due to extensive research and development. There are still many phenomenon which are not understood fully [13]. Srivastava, N., & Haque, I., A review on belt and chain continuously variable transmissions (CVT): Dynamics and control,2015. This paper summarizes the existing methods of analysis at home and abroad from the perspective of strong Diagnostics of Electromagnetic Friction Brakes and Clutches present, including principle and current status. At last, several critical problems in nondestructive testing of wire rope are discussed [14]. Bochkarev, Igor V., Diagnostics of Electromagnetic Friction Brakes and Clutches,2019. This paper proposes and theorizes upon a new method for diagnosing movable-armature electromagnetic mechanisms (EM), which is based on an additional high frequency electric-field effect on the EM magnetic core; the field excites corresponding high-frequency electrodynamic processes that are not related to the EM operating parameters and do not affect them in any way. The EM winding is used as an electromagnetic control sensor, which registers the diagnostic parameters of highfrequency electrodynamic processes, whose value depends on the current status of the EM [15]. Peng, P. C., & Wang,, Research on Radiographic Testing of Steel

Wire Ropes in Suspension Bridges,2016. This study is concerned with the development of nondestructive testing techniques to investigate the steel wire ropes in suspension bridges. In this research, a radiographic testing is approached to evaluate the steel wire ropes were coated with plastic materials [16]. Dr Ing C. Erdem IMRAK & MSc Eng Mustafa OZKIRIM, Structures and Selection of Wire Ropes for Elevators, In the elevator installations, wire ropes are used to suspend the cars and the counterweights. Wire ropes in elevators are of round stranded and usually of right hand lay. Service life of elevator ropes depends on a number of factors such as wrap angle and lubrication. In this study types and structures of wire ropes are examined and compared. Then selection of elevator wire ropes is explained and service life of ropes is discussed in accordance with the standards [17]. Sumit Kumar, Rajeev Kumar, Harish Kumar, Analysis & Investigation on Watt Governor to Improve the Speed Range of the Governor,2016. Watt governor is the oldest governor. And the various modifications are made in the watt governor according to the requirement. Porter and Proell are the modified form of the watt governor. Here in the current paper the modification is made for increase the working range of the watt governor. And it is concludes that the working speed range can be enhanced by the modification discussed [18]. Nima Jamshidi a., Sayed Mohamad Abdollahi , Ali Maleki 2016, A survey on the actuating force on brake and clutch pedal controls in agricultural tractor in use in Iran , The results obtained by testing the three conditions on JD3140 and U650 tractors regarding muscular disturbance indicated more safety for the operator. The least diversion was with JD950, where, in relation to different anthropometrics, there were less sensitivity and exposed similar angles in the knee joint. The lowest knee joint average observed in MF285 at the maximum force was inflicted on the pedal at the minimum knee extension [19].Enrico Ronchi, Daniel Nilsson , Fire evacuation in high-rise buildings: a review of human behaviour and modelling research,2013. This paper presents the findings of a literature review conducted on human behaviour and modelling research for high-rise building evacuations. Three categories of high-rise buildings have been taken into account, namely office buildings, residential buildings and health care facilities. The individual or combined use of egress components has been analysed as well. The review shows that the effectiveness of the egress components is associated with the building use and the population involved [20]. Ali Hasan, Study of Watt Governor Mechanism,2021, From the graph ‘Fc’ Vs ‘r’ , it is evident that for a very small change in ‘r’, there is a tremendous change in ‘Fc’ acting on fly balls. From Nact Vs ‘x’ graph , there is a little increase in ‘x’ with increase in ‘Nact ’. Also, from ‘Ntho’ Vs ‘x’ graph, there is a little increase in ‘x’ with increase in ‘Ntho’. In other words, with slight change i.e. increase in rpm, ‘Fc’ increase, increasing the ‘r’ resulting in increased ‘x’. As the speed decreases, ‘r’ decreases slightly resulting in lowering of the sleeve [21]. Roczek, K., & Krol, A., Clutch-Brake Unit - Principle of Operation and Basic Diagnostic Methods, 2018, The Clutch-Break unit requires renovation and plates replacement. Independently on plates thickness it seems that the friction surface is worn. The second thing that has to be checked is hydraulic unit that provides improper oil pressure in case of soft breaking. In some cases, the gaps measurement result suggests that the plates thicknesses are according to standard, but in spite of that one may observe that operation of C-B doesn’t work [22]. C. Brecher & M. Esser, S. Witt, CIRP Annals - Manufacturing Technology 58 ,2009, Interaction of manufacturing process and machine tool, For a wide variety of metal-working processes, the state-of-theart and the state of ongoing research in process– machine interactions have been presented. The large number of projects demonstrates the strong interest in the related research. In cutting and grinding, there is a long tradition of viewing theprocess and the machine tool as an interacting system. Researchers of forming processes have started to consider press behaviour over the last few years. In all disciplines, there are more or less four important steps in the research of process–machine interaction [23].Asim Rashid,Int.J. Vehicle Noise and Vibration, Vol.10, No.4, pp.257..301, Overview of Disc Brakes and Related Phenomena – a review,2014. Disc brake is a complex system and understanding different issues related to its design and operation require expertise from different disciplines e.g. tribology, material science, fluid dynamics, vibrations etc. Disc brakes have evolved a lot over the decades due to extensive research and development. There are still many phenomenon which are not understood fully [24]. Das, S., Siddiqui, R., & Bartaria, V. , Evaluation Of Aluminum Alloy Brake,2016. Drum For Automobile Application, Brake drums are made of Al-Si ADC12 and LM30 alloys and their braking ability is evaluated on a dynamometer. The coefficient of friction between the liner and drum materials, temperature rise at the inner and outer surface, stopping distance, and braking effectiveness were determined at speeds of 700, 1000, and 1300 RPM under varying loads [25].

#Summary of literature survey :

i. The methodology and current state of wire rope non-destructive examination are covered in the study, along with viewpoints from strong magnetic and weakly magnetic fields. Additionally, it draws attention to important problems with wire rope testing. ii. The review examines shaft design and comes to the conclusion that vertical shafts are generally preferred. Rectangular shafts could become outdated, while circular and elliptical shafts are seen as the way of the future. iii. The study

gives a general review of disc brakes, emphasising their complexity and the demand for knowledge from numerous fields. It describes the development of disc brakes as well as a number of phenomena that are still not completely understood. iv. The analysis techniques for belt and chain continuously variable transmissions (CVT) that are now in use are compiled in this work from both domestic and international viewpoints. It examines CVT dynamics and control and points out significant issues with its testing. v. The importance of wire ropes and their uses in numerous sectors are emphasised in the paragraph. The difficulties with non-destructive testing are highlighted,including their low dependability, low intelligence, lack of objectivity in test results, and insufficient knowledge of wire rope damage. vi. The study suggests a novel approach based on high-frequency electric field effects for the diagnosis of movable-armature electromagnetic mechanisms. It advises recording diagnostic parameters using the mechanisms' electromagnetic control sensor. vii. The varieties, constructions, selection, and service lives of wire ropes used in lifts are all examined in this essay. It describes the selection procedure in accordance with standards and places emphasis on elements like wrap angle and lubrication.

2. Body of Paper

Design of Emergency Fire Rescue Machine(EFRM):

#Construction and working

Frame: It is rigid metal body structure whose foremost function is to carry the load of person and all the mechanical components. A frame is intended to carry and distribute loads, resist forces, and preserve the system's overall structural integrity. It is built up of linked elements that are frequently constructed of structural materials such as steel or aluminium and are organised in a certain form to produce the appropriate strength and stiffness.

Shaft: A shaft is a spinning machine member that transmits power, torque, or motion between various mechanical system components. Shafts are generally cylindrical in shape and may be found in a variety of applications, including engines, pumps, conveyors, turbines, and a variety of other rotating systems.

Brake mechanism: Brake mechanisms are important components for controlling and stopping the motion of rotating or moving devices. Brakes are used to assure safety, control speed, and prevent undesired motion in a variety of applications, including automobiles, industrial machinery, and equipment.

Governor: A governor is a mechanism that regulates and controls the rotational speed of equipment. It's common in engines, turbines, generators, and other mechanical systems that need accurate speed control. A governor's primary role is to keep the machine running at a reasonably constant speed under variable load situations.

Rope: Ropes are frequently employed as flexible parts for conveying forces, sustaining weights, and allowing mechanical systems to function properly.

Bearing: Bearings assist and facilitate the movement of rotating or sliding components inside a machine or mechanical system. They are intended to eliminate friction, support weights, and offer smooth, consistent motion.

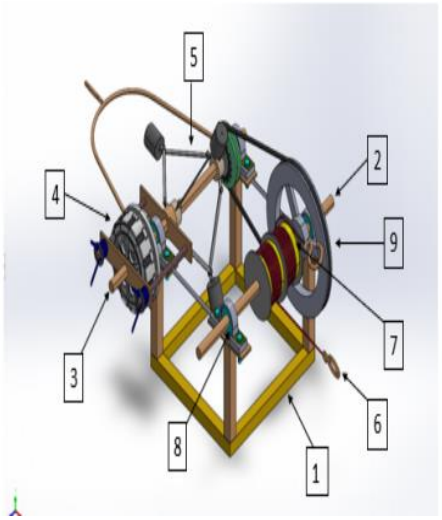
Pulley: A pulley is a basic mechanism that consists of a grooved wheel and a rope or belt running along the groove. Pulleys are employed in a variety of applications to convey power, change the direction of force, or offer mechanical advantage.

#Working: In the Emergency Fire Rescue Machine, when the rope is pulled in downward direction due to weight of person, the reel shaft rotates, this rotary movement of reel shaft is transferred to governor shaft via belt and pulley system which is used as transmission system. As the angular velocity of governor shaft increases, the governor's dead weight tends to move in outward direction due to centrifugal force acting on it. This centrifugal force actuate the brake mechanism due to interlink-ability and synchronous operation. The Emergency Fire Rescue Machine can be accessed by 2 persons simultaneously as it employees 2 ropes wounded on reel shaft one in clockwise and other in anticlockwise direction. This machine is reusable and can be accessed by multiple people.

#Manufacturing: A cutting operation is the removal of material from a workpiece using a cutting tool to shape, size, or finish it to particular specifications. Cutting procedures are widely utilized in many sectors, including manufacturing, machining, metalworking, and woodworking. The frame members of machine produced after the primary cutting operation. Larger members are base of the frame and smaller ones are the four legs of frame. The process of fastening and keeping metal workpieces in place throughout various manufacturing activities is referred to as metal fixturing. Fixturing is required to guarantee that machining or manufacturing operations are accurate and consistent. TIG (Tungsten Inert Gas) welding, often known as GTAW (Gas Tungsten Arc Welding), is a common metal joining procedure. It entails the employment of a nonconsumable tungsten electrode, an inert gas shield (usually argon), and (if necessary) a filler metal.A UCP (Unit Bearing, Pillow Block Bearing) is a type of bearing unit that is widely seen in mechanical systems. It comprises of a bearing contained in a pillow block, which provides the bearing with support and stability. Belts and pulleys are mechanical components used in power transmission systems that are used to convey rotational motion and power between two or more shafts. Belts are elastic loops

formed from materials such as rubber, nylon, or leather. They wrap around pulleys to transfer power from one shaft to another.A multiplate clutch is a mechanical clutch that engages and disengages power gearbox between the engine and the drivetrain in automobiles and machines. It is made up of many alternating friction plates placed between a pressure plate and a driven plate.

#Testing: After successful manufacturing of Emergency Fire Rescue Machine, our prime goal is to carryout testing of developed prototype. In the testing, we are going to measure the actual time taken by person for safe landing from four floor rise building. Our second objective is to synchronisation of brake and governor mechanism during their operation and also to visually inspect the bending to shaft and frame. In the compete testing procedure, we have made use of multiple instruments like digital stopwatch to measure the time taken for safe landing, measuring tape to measure the heights and weighing machine to weigh the dead weights of governor.



Number	Name Of Component
1	Frame
2	Reel Shaft
3	Governor Shaft
4	Brake Mechanism
5	Governor
6	Rope
7	Reel
8	Bearing
9	Pulley

Fig : Emergency Fire Rescue Machine.

3. CONCLUSIONS

Emergency Fire Rescue machine's manufacturing is done by considering every single parameters, such that it should be cheap, affordable, effective operation, requires optimal time for safe landing of person and it aims to provide society a cost effective and safe solution over fire accidents. The results fetched from CAE software and the theoretical values consider for calculations are almost close to each other with accepted percentage error. The cost of Emergency Fire Rescue Machine is Rs.12,360/- which is quite affordable for the society when compared with the skysaver technology whose cost is Rs. 75,000/-. The skysaver device is used only by single person and cannot be reused again but the developed Emergency Fire Rescue Machine is multiple use device which can be accessed by 2 person at a time and thus increasing the number of evacuates with safe landing from the rise-building. The taken by the Emergency Fire Rescue Machine for landing is in the range of 0.2m/s to 0.26m/s which is almost near to theoretical value i.e. 0.2m/s.

1. We have successfully designed and developed a Emergency Fire Rescue Machine operating for 4 floor building.
2. Selected Clutch Brake, Centrifugal Governor and Belt and Pulley Transmission system with its effective functioning.
3. We performed structural analysis and validated all components using FEA tool.

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