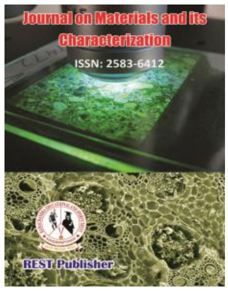
Journal on Materials and its Characterization
Vol: 3(4), December 2024
REST Publisher; ISBN: 2583-6412
Website: http://restpublisher.com/journals/jmc/
DOI: https://doi.org/10.46632/jmc/3/4/6



Penstock Material Selection in Hydropower Plants Using EDAS Method

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Abstract. *Due to the severe working circumstances and the lengthy service life anticipated from these structures, choosing suitable materials for penstocks in hydropower plants is a crucial task that demands careful attention. The assessment and choice of penstock materials in hydropower plants is the main focus of this study's use of the EDAS (Evaluation based on Distance from Average Solution) approach. The EDAS technique optimises the decision-making process by combining the benefits of objective as well as subjective criteria. Introduction: To ensure the effective and consistent operation of these structures, it is essential to use the right elements for penstocks in hydropower plants. Penstocks are crucial parts that transport highly pressurised water from the reservoir to the turbines, where the energy is captured to produce power. The selection of penstock materials is crucial in determining the durability and efficiency of the hydropower plant due to the rigorous operating circumstances, such as high pressures, turbulent flow, and probable exposure to corrosion. His research aims to develop the methods for choosing penstock materials, ensuring the efficient and dependable operation of hydropower plants in spite of difficult environmental circumstances and long lifespan expectations. Research significance: In order to improve durability, operational efficacy, affordability, environmental sustainability, and safety, penstock material research is essential for hydropower plants. The results of this type of study can help the industry make decisions that maximise the efficiency and durability of hydropower facilities. Method: Using the EDAS technique, decision-makers can objectively assess and rank alternatives while methodically taking into account a variety of criteria. It aids in the facilitation of informed decision-making in difficult situations by taking into consideration both the relevance of criteria and the distances from the typical solution. Alternate parameters: Poly vinyl chloride (PVC), High-density polyethylene (HDPE), Glass reinforced plastic (GRP), Mild steel (MS) Evaluation parameters: Yield strength (YS), Life (L), Thickness (T), Material cost(C), Maintenance cost (MC). GRP got 1st rank, MS got 2nd rank, PVC got 3rd rank and HDPE got 3rd rank. GRP got 1st rank with less compensation.*

Keywords: *Penstock material selection, hydropower plants, EDAS method, decision-making, criteria, performance evaluation.*

1. INTRODUCTION

The plant's components are the powerhouse, fast tube (penstock), spillway, silent pond, dam or weir and carrier Channel, exhaust pipe, and actuator Room. The dam's initial components having the entire facility and water flow across it operate the river. Its purpose is to keep water in a certain location. It is the point where water entering the facility is handled. It is near the dam's Carrier Channel exit. As a conduit, carrier channel transports water to a power loom pressure is a fast pipeline or penstock pipeline supplying a still pond with water as a water turbine [1]. The majority of penstock problems occurred in buildings under 50 years old or new. Including a thorough penstock inspection programme is the primary goal of adopting a penstock safety programme. The task is to make sure that every penstock is used, maintained, and operated safely and effectively. Key advantages of regular penstock inspections have the greatest benefits [2]. There are analyses of different penstock products taking into account factors like corrosion, weight, cost, and friction. Use couplings and a pressure penstock, which can represent up to 40% of the project's overall cost, are frequently more expensive but necessary for the MHP system to function dependably. There are several factors to consider when determining which material to use for a particular penstock design. Factors include the pipe's inner surface roughness, connecting method, weight, simplicity of setup, site access, design life, maintenance requirements, corrosion, accessibility, relative cost, and risk of damage to the structure. The high pressure grade of the penstock is essential because the pipe wall must be thick enough to support the highest water pressure else there's a risk of an explosion. The penstock's water pressure is dependent on the more head [3]. Penstock problems include leaks at expansion joints, seal deterioration, gland leaks, and outer layer corrosion. As it joins the stream, the water is guided in the direction of the power plant. A dam and inlet that receives notice in advance from a power channel diverts water. Water from the forebay is directed through a penstock to power the powerhouse's turbines [4]. The only source of hydropower generation depends solely on the substance used for the penstock and how strong the pipe is. The electricity generated in a turbine (lost from the water potential energy) is given regardless of the water's course through the pipe channel or penstock. During the penstock, turbulent conditions may develop [5].The penstock is a crucial component of a hydropower plant. It is a gate or intake system, or a closed conduit that feeds or regulates water flow for sewage systems and hydro turbines. It's a word that evolved from previous mill pond and water plant technologies. Determining the diameter, thickness, and material utilised in penstock design is important. Rate of flow, Q = Ap x Vp [6]. The material replacement evaluation procedure is essential. The selection of penstock material is straightforward, but there are many options available. The criteria and intricate connections between them make this a difficult task. The lack of clear and appropriate measuring rules, criteria, or projects is typically seen as a general MCDM problem. As a result, rather than using numerical or simulation approaches, the process of evaluating alternatives is generally based on trustworthy experiences from professionals in the field. Numerous earlier studies have examined and suggested various contexts and methods for conducting research on the topic in the literature. The social, technological, environmental, or economic sector selection dilemma and adopted impact criteria [7]. The utilisation of seawater in PSS brings about a number of issues, mostly of a technical nature. Sea water loss from upper reservoirs or Penstock might have negative environmental effects. The two primary technical problems that must be overcome as a result are the sealing of the reservoir and the use of corrosion-resistant materials for the penstock. Seawater has to be transported by breeze from the top reservoir's surface. All hydrodynamic machinery (pump, hydro turbine, etc.) must employ corrosion-resistant materials. Given the potential for extreme weather on the site, the location of hydrodynamic stations along the shoreline and the supply of seawater from the sea to the reservoir should be evaluated [8]. These experiences led to the development of a new methodology for defining eligibility requirements for using high strength steel grades for hydropower applications. The specifications for high strength steel to be chosen for design, manufacture, and service ensure that penstocks and steel-lined shafts meet the specifications. Their integrity, with the exception of weldability and proper use fabrication techniques Strength and Fortitude Using the best non-destructive testing techniques and methods, fatigue characteristics for fixed load situations, changing loads, propensity to stress corrosion cracking, and more [9]. The break caused the entire pipe above the opening to fall apart. The dresser connection's anchor block is removed from the pipe just upstream and next to it. The settling basin could be emptied thanks to the opening caused by the shattering and dislodging of the dresser attachment. Some minor damage occurred. The penstock supports were in good shape, and there was no corrosion in that section of Penstock Path, a neighbourhood eatery along the high road. It is challenging to hydrate the structure since both the quiescent basin and the turbine inlet valve is leaking, leaving the penstock inner surface exposed to the atmosphere. The ensuing moist environment made it easier for the exposed materials on the inside surface of the penstock to corrode quickly [10]. Supplying possible energy in exchange tunnels like penstocks, water from bodies of dams or natural lakes is transformed into motion energy. Turbines are used to transform water into mechanical work. A gear system may be used to connect the turbine shaft to the generator rotor directly. a result of the generator's rotor's induced windings. A magnetic field is created around the rotor when a direct current force is applied, and electricity is generated by igniting the stator windings. This energy was transferred to a networked system that included power transmission lines, transformers, circuit breakers, and disconnections [11]. At Helms, penstock field welds are now inspected in accordance with a set inspection programme based on DFM techniques. Evaluation of the field welds (FWs) around the penstock is the purpose of the paper is to show how the PFM approach can be used to justify shorter inspection periods than would be necessary if applied. The Helms Pumped Storage Project by Pacific Gas and Electric Company, which uses penstock FWs, offers a specific illustration of the implementation of PFM. This investigation focused on three of the field welds close to the powerhouse [12]. It will be required to improve the turbine-penstock characteristics as hydraulic turbine and hydropower head unit capacities rise in the future. The required strength of the penstock material is largely determined by the penstock diameter. Because the shell thickness of the turbine penstocks approaches critical values (60–70 RAM) in this situation, the strength qualities of standard environmentally friendly and low-alloy steels are practically exhausted for the pen stocks used in contemporary high-efficiency hydraulic turbines. The mechanical and fragile strength of welded joints, as well as the dependability of welded construction in general, are all impacted by additional increases in penstock wall thickness, which also result in a significant rise in the labour costs associated with assembly and welding Work [13]. When the guiding cylinder collapses, the screws at the fixed end become loose due to flow-induced vibrations, which are mostly caused by penstock expansion joints. With respect to the unique structural formulation and the nature of the guiding cylinder's loads, we can connection quality and reliability are the key elements determining the stability and safety of expansion joints. Cantilever tip vibration caused by flow and the fixed end's shape. Use the viewpoints mentioned above. We conducted a specific flow-induced vibration model test and three-dimensional finite element analysis in order to address the stability and safety issue of water diverting penstock expansion joints in several hydropower facilities [14]. Through hydrodynamic and hydro elastic experiments, we received loads that are variable in nature upstream and downstream of the guide cylinder. Analyse and assess the guiding cylinder's vibration properties, then consider stability and safety expansion joints and a guide cylinder. Using three-dimensional finite elements and model testing Analysis of existing static fatigue and penstock expansion joints in several power plants Analytical techniques seek to discuss the guiding cylinder's safety from the viewpoint of the thesis. To evaluate the safety of expansion joints, consider the wear on the welding structure [15].

2. METHODOLOGY

A new multivariate estimator (MCDM) method called estimation based on distance from the mean solution (EDAS) is based on how far the alternatives are from the average scores for the attributes. In the event of fuzzy and missing data, traditional EDAS has previously been extended using conventional fuzzy sets. In this research, we offer a membership data, non-membership, and levels of reluctance-based interval-valued logical fuzzy EDAS approach. To demonstrate how reliable results are produced, a sensitivity evaluation is also shown utilising the suggested intuitive fuzzy EDAS. Numerous issues are addressed using the proposed intuitionist fuzzy EDAS methodology [16]. The EDAS technique was recommended by Ghorabaee et al. (2015) for categorising their products. Compared to other classification techniques, EDAS offers significantly better results and requires fewer mathematical operations. When adopting the upgraded EDAS supplier identification approach, each alternative is evaluated based on how far it deviates from the accepted response relative to each criterion. Choosing the location for the disposal of solid waste can be done using a straightforward fuzzy approach built on EDAS, according to Kahraman et al. (2017) [17]. The EDAS approach was initially recommended for comparing various steam boiler alternatives, and the MACBETH method is utilised to determine the values of the evaluation criterion. Then, several steam boiler options are ranked using the EDAS methodology. In the end, the ideal boiler substitute is picked. To address concerns with company selection, numerous Multi-Criteria Decision Making (MCTM) strategies have been put forth. There are other places in the literature where the MCDM techniques Macbeth and EDAS are used [18]. In the EDAS technique, language characteristics, such as ambiguity and imprecision, may affect how decision-makers evaluate the decision matrix. With its recently created extensions, fuzzy set theory is a helpful tool to deal with this kind of ambiguity. Some EDAS-Based Techniques for Smooth Choice Making with Neutrosophic Sets [19]. EDAS approach the Neutrosophic set has been expanded for the first time. Benefits of these packages include relativistic reflection of experts, completeness, and subset independence it is a neutrosophic synthesis. Experts have a lot of freedom to propose values for subgroups because of this freedom Recommended all of the benefits that neurotrophic aggregates have over other confusing aggregate types are included in the neurotrophic EDAS approach [20]. Certain traditional MADM techniques find it difficult to deal with very uncertain material that contains strong ambiguity, ambiguity, and inaccuracy. In view of the aforementioned issues, fuzzy set theory is a useful method to define MADM with uncertain knowledge. As a result, many researchers have enhanced the conventional MADM methods with fuzzy surrounds. The EDAS (Estimation Based on Distance from Average answer) approach has been added to the MADM method through queries with regard to positive as well as negative distances from the average answer and application to the issue of stock [21]. The strategy has been broadened to address problems with group decision-making in a linguistic neurosophic context. a chart An example of picking an asset management company is given to show the efficacy and practicality of the proposal technique. EDAS is a practical and easy to compute method for differentiating scenarios that has been used in multi-criteria inventories selecting a source after sorting. Despite the lack of recent study on EDAS, some users have demonstrated that its results are highly compatible with other strategies [22]. There is a method called EDAS, High performance with minimal calculation in addition, as opposed to other ways of decision-making, in order to determine compatibility. A computer example of rating green suppliers uses the expanding technique. Consequently this approach is proven to be simple to comprehend and use. Among other issues of choice, the right solution can be chosen using this approach [23]. Practicality this study proposes the EDAS technique using a process as an illustration. An average solution is used in the EDAS approach assessing potential choices to achieve the typical outcome [24]. Multi-criteria decision making (MCDM) problems are solved using the EDAS method in this research. Our driving force this latest addition lacks direction what do sets with interval values look like it uses the EDAS system [25].

Alternate Parameters

1. Polyvinyl chloride, or PVC, is a synthetic thermoplastic polymer that is widely employed in a variety of fields and applications. It is a multipurpose material renowned for its resilience to chemicals and affordability. The polymerization process of vinyl chloride monomers results in the creation of PVC.
2. High-density polyethylene, sometimes known as HDPE, is a kind of thermoplastic polymer created from ethylene monomers. It is a flexible material renowned for its excellent strength, toughness, and resistance to damage from chemicals, impacts, and the elements. Due to its advantageous combination of qualities, HDPE is widely employed in many different sectors and applications.
3. A composite material called glass-reinforced plastic is made of a plastic matrix with glass fibres for reinforcement. It is a sturdy, light-weight material with outstanding mechanical qualities that may be used in a variety of applications.
4. Mild steel is a form of carbon steel with relatively low carbon content in its composition. It is sometimes referred to as low carbon steel or plain carbon steel. Because of its low cost, wide range of applications, and simplicity of manufacture, it is one of the most popular and commonly utilised varieties of steel.

Evaluation Parameters

1. A material's yield strength, which is a mechanical parameter, determines the highest stress that it can sustain without deforming plastically. It indicates the tipping point between a material's elastic behaviour, which allows it to recover its former shape after being stressed, and plastic behaviour, which causes it to deform permanently.
2. Scientific investigation, statistical analysis, and long-term observations are frequently used to estimate an organism's life expectancy. It is a crucial factor to take into account in industries like biology, ecology, engineering, and product development since it influences choices about sustainability, maintenance, replacement, and planning.
3. The cross-sectional size of a material, or the gap between its interior and exterior surfaces, is what is referred to as a penstock's thickness.
4. The term "material cost" describes the cost of the components or raw materials needed in the manufacture or building of a good or project. It indicates the cost incurred to purchase the materials required to manufacture, assemble, or complete a particular task or project.
5. The costs incurred to maintain, repair, or restore the functionality, dependability, and health of assets, equipment, or infrastructure during the course of their operating existence is referred to as maintenance costs. It stands for the monetary resources needed to carry out routine inspections, carry out preventative maintenance tasks, and attend to corrective or reactive maintenance requirements.

3. RESULT & DISCUSSION

TABLE 1. Penstock Material Selection in Hydropower plants.

Materials	YS()Mpa	L(year)	T(mm)	C($/m)	MC($/m/year)
PVC	26	12	40	863.59	17.26
HDPE	34	25	46	1239.61	37.19
GRP	138	40	8	470.42	7.05
MS	252	50	9	630.65	37.84

Table 1 shows that the Penstock Material selection in hydropower plants with Alternate parameters: Poly vinyl chloride (PVC), High-density polyethylene (HDPE), Glass reinforced plastic (GRP), Mild steel (MS) and Evaluation Parameters: Yield strength (YS), Life (L), Thickness (T), Material cost(C), Maintenance cost (MC)

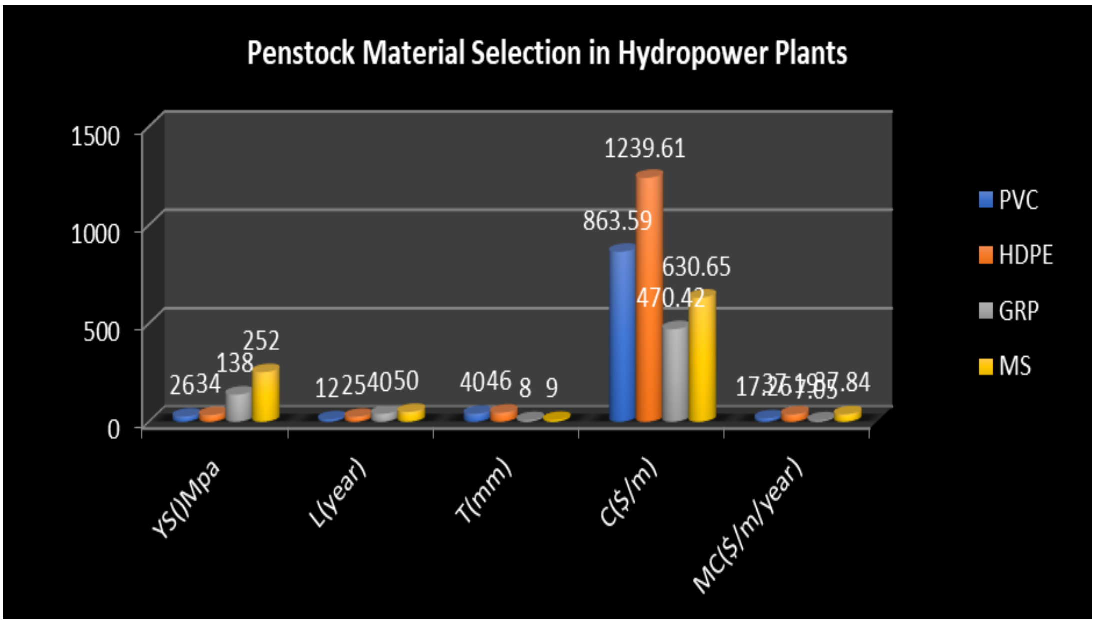

FIGURE 1. Penstock Material Selection in Hydropower plants.

TABLE 2. Positive Distance from Average (PDA)

Materials	Positive Distance from Average (PDA)				
PVC	0	0	0.5534	0	0.305
HDPE	0	0	0.78641	0	0
GRP	0.227	0.259843	0	0.4128	0.7159
MS	1.24	0.574803	0	0.2127	0

Table 2 shows that the Positive Distance from Average (PDA) for all the Alternate & Evaluation Parameters.

TABLE 3. Positive Distance from Average (PDA)

Materials	Negative Distance from Average (NDA)				
PVC	0.76889	0.622047	0	0.078052	0
HDPE	0.69778	0.212598	0	0.547447	0.497379
GRP	0.00000	0	0.68932	0	0
MS	0.00000	0	0.650485	0	0.523585

Table 3 shows that the Negative Distance from Average (NDA) for all the Alternate & Evaluation Parameters.

TABLE 4. Weightages

Materials	Weightages				
PVC	0.2	0.2	0.2	0.2	0.2
HDPE	0.2	0.2	0.2	0.2	0.2
GRP	0.2	0.2	0.2	0.2	0.2
MS	0.2	0.2	0.2	0.2	0.2

Table 4 shows that all the Benefit & Non-Benefit Parameters Have equal weight.

TABLE 5. Weighted PDA

Materials	Weighted PDA				
PVC	0	0	0.11068	0	0.061
HDPE	0	0	0.15728	0	0
GRP	0.045	0.051969	0	0.0826	0.1432
MS	0.248	0.114961	0	0.0425	0

Table 5 shows that the Weighted Positive Distance from Average (PDA) for all the Alternate & Evaluation Parameters.

TABLE 6. Weighted NDA

Materials	Weighted NDA				
PVC	0.15378	0.12441	0.00000	0.01561	0.00000
HDPE	0.13956	0.04252	0.00000	0.10949	0.09948
GRP	0.00000	0.00000	0.13786	0.00000	0.00000
MS	0.00000	0.00000	0.13010	0.00000	0.10472

Table 6 shows that the Weighted Negative Distance from Average (NDA) for all the Alternate & Evaluation Parameters.

TABLE 7. SPi & SNi

Materials	SPi	SNi
PVC	0.17169	0.29380
HDPE	0.15728	0.39104
GRP	0.32304	0.13786
MS	0.40551	0.23481

Table 7 shows that the value of SPi & SNi for all the Alternate Parameters.

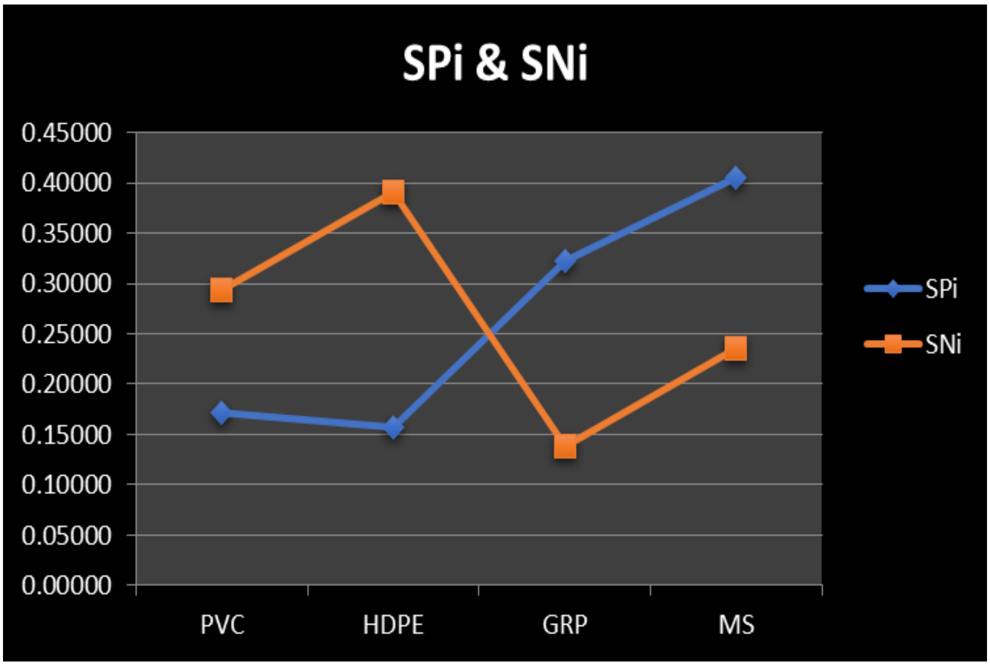

FIGURE 2. SPi & SNi

TABLE 8. Normalized SPi & SNi

Materials	NSPi	NSNi
PVC	0.423384	0.248677
HDPE	0.387862	0
GRP	0.796628	0.647443
MS	1	0.399515

Table 8 shows that the value of NSPi & NSNi for all the Alternate Parameters.

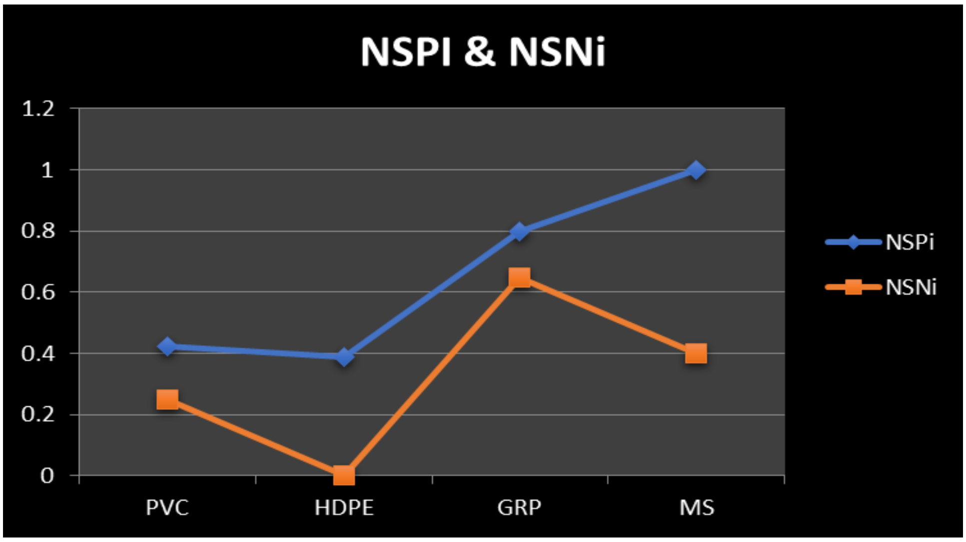

FIGURE 3. NSPi & NSNi

TABLE 9. ASi & Rank

Materials	ASi	Rank
PVC	0.33603	3
HDPE	0.193931	4
GRP	0.722036	1
MS	0.699757	2

Table 9 shows that the ASi values and Rank for all the Alternate Parameters.GRP got 1st rank, MS got 2nd rank, PVC got 3rd rank and HDPE got 3rd rank.

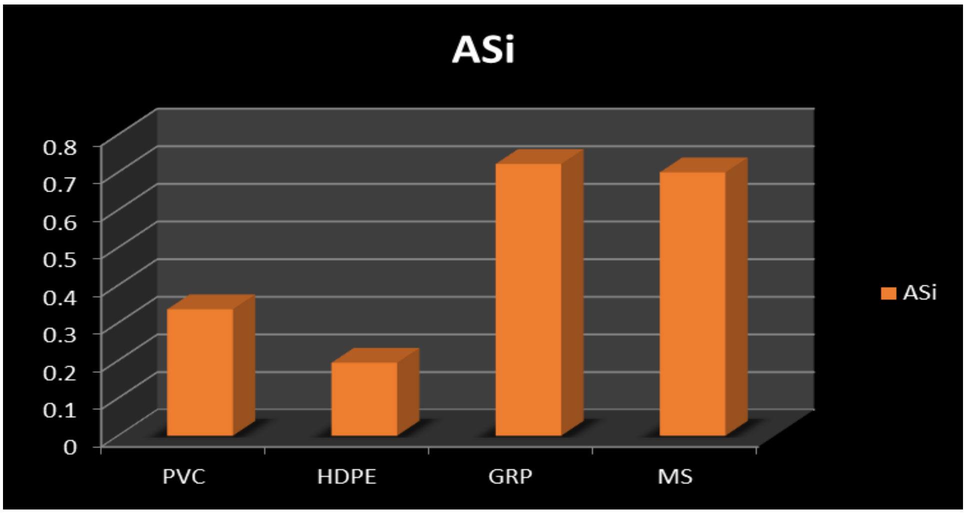

FIGURE 4. ASi

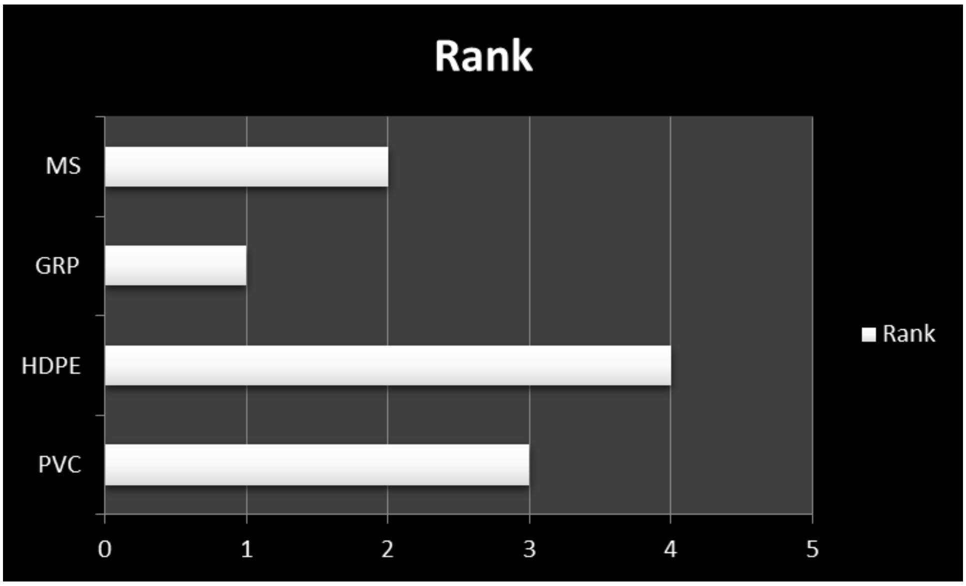

FIGURE 5. Rank

From Figure 5, it is clear that GRP got 1st rank with less compensation.

4. CONCLUSION

To ensure the effective and consistent operation of these structures, it is essential to use the right elements for penstocks in hydropower plants. Penstocks are crucial parts that transport highly pressurised water from the reservoir to the turbines, where the energy is captured to produce power. The selection of penstock materials is crucial in determining the durability and efficiency of the hydropower plant due to the rigorous operating circumstances, such as high pressures, turbulent flow, and probable exposure to corrosion.His research aims to develop the methods for choosing penstock materials, ensuring the efficient and dependable operation of hydropower plants in spite of difficult environmental circumstances and long lifespan expectations. In order to improve durability, operational efficacy, and affordability, environmental sustainability, and safety, penstock material research is essential for hydropower plants. The results of this type of study can help the industry make decisions that maximise the efficiency and durability of hydropower facilities. The material replacement evaluation procedure is essential. The selection of penstock material is straightforward, but there are many options available. The criteria and intricate connections between them make this a difficult task. The lack of clear and appropriate measuring rules, criteria, or projects is typically seen as a general MCDM problem. As a result, rather than using numerical or simulation approaches, the process of evaluating alternatives is generally based on trustworthy experiences from professionals in the field. Numerous earlier studies have examined and suggested various contexts and methods for conducting research on the topic in the literature. The social, technological, environmental, or economic sector selection dilemma and adopted impact criteria. There is a method called EDAS, High performance with minimal calculation in addition, as opposed to other ways of decision-making, in order to determine compatibility. A computer example of rating green suppliers uses the expanding technique. Consequently this approach is proven to be simple to comprehend and use. Among other issues of choice, the right solution can be chosen using this approach. Rank for all the Alternate Parameters are GRP got 1st rank, MS got 2nd rank, PVC got 3rd rank and HDPE got 3rd rank.

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