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Manufacturing of Foldable Bicycle with Finite Element Analysis of Push-Pull Clamp

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Abstract. Due to time constraints and a hectic lifestyle, the modern man is unable to set aside a certain amount of time for his health. Exercise and physical fitness are therefore accorded less priority. To make up for the lack of time, we can use the time spent travelling by bicycle to exercise effectively, helping to reduce pollution. However, conventional bicycles require enough space to park, are difficult to transport, and are vulnerable to theft. Transport has been one of the most crucial issues to be resolved in the current situation because moving about the city has grown to be a time-consuming and expensive process. It is quite challenging to get to the nearest public transportation hub, and frequently, the destination will be relatively far from major thoroughfares, making it impossible or expensive for public transportation to access. The concept of creating a folding bicycle was developed to address a prevalent issue facing society. Although there are currently a lot of folding bicycles on the market, the major goal of this project is to create one that is lightweight, elegant, robust, and safe. simple to handle and keep up. This bicycle will take up much less space than a normal bike and is also incredibly portable. The major goal is to create a foldable bicycle that is both inexpensive and comfortable to ride.

INTRODUCTION

Due to time constraints and a hectic lifestyle, the modern man is unable to set aside a certain amount of time for his health. Exercise and physical fitness are therefore accorded less priority. One of the prevalent problems in today's culture is obesity, which creates a number of health risks. Exercise is recommended for both health maintenance and the treatment of various disorders. Aerobic activities are suitable for these purposes among the others. There are numerous ways to engage in aerobic exercise, including running, jogging, walking, cycling, and others [1].

In booming cities like Bangalore, transportation has become a significant problem because getting from one point to another has grown time-consuming and expensive. while the cost of gasoline and diesel rises daily. The cost of almost all forms of transportation is rising. It is challenging to get to the closest public transportation hub, and frequently, the destination is off-the-beaten-path and out of reach for public transportation because of narrow roads. To get around this, most individuals drive their own cars, which causes problems with parking, traffic, etc. But because owning a car is so expensive, not everyone can choose to do so [2].

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Bicycles are one answer that springs to mind when considering such problems as health, transportation, parking space, etc. Corporate and academic sectors both promote bicycle use. But how practical is riding a standard bicycle? One of the concerns that prevents people from using bicycles is that there is frequently no particular facility offered for locking the bicycles, and even if one is available, it is likely to be stolen. It is tough to provide a traditional bicycle at work or at home because they take up enough room. They likely will be exposed to the elements outside and do need regular care.

The use of a foldable bicycle is the next potential solution to all these problems with traditional bicycles. With foldable bicycles, there is never a problem because the bike can be folded and transported to the workplace or even utilised to get to the closest public transportation facility before being folded and transported farther. The bicycle takes up very little room and doesn't need a separate parking location because it is folded. Since they are easily transported inside of buildings, they are not exposed to the elements and require less care[3].

The use of foldable bicycles makes it possible to combine the various forms of transportation outlined above, which helps reduce some of the costs associated with travel. The greenhouse effect, which is primarily brought on by the generation of carbon dioxide, sulphur dioxide, nitrous oxide, and other gases, is the main culprit behind these negative impacts.

One thing is obvious from research dating back to 1896 to the current day: our means of transportation is where the majority of harmful gases are produced. These types of toxic pollutants are produced in great quantities by them and released into the atmosphere, where they contribute to the greenhouse effect and other dangerous situations. As a result, in order to lessen and control this, the main emphasis is on reducing the amount of hazardous pollutants produced by automobiles. To this end, research advances and studies are being undertaken on forms of mobility like bicycles, which almost completely lack in pollutant output. Cycles have been a significant means of mobility in our planet since very early times. It is an excellent tool for reaching and preserving good physical and mental health in addition to being a means of mobility [4].

In addition, it costs the least to operate and maintain, making it the most affordable means of transportation. Due to the fact that it generates only 05 pollution, it is also the most environmentally friendly form of transportation ever created. In addition, it is a relatively accessible and affordable means of transportation. The upgraded and improved version of the cycles is the folding bicycle. It is the type of cycles that is elevating the cycles' legacies to new levels. Their features and benefits, such as light weight, portability, ease of use, need for less space, and low maintenance requirements, are increasing their popularity [4].

AIM and Need

A foldable bicycle is designed to be conveniently folded and transported wherever you go. Because of its bending and adjustable frame, it is also simpler to fold and store. You can do this to bring your bicycle inside of structures, on public transportation, and even on aero planes.

One of the most practical means of getting from one location to another is by bicycle. There are many methods to commute, including by bike, rail, and bus, but they are all expensive for campers bicycles. A bicycle costs roughly 10–12 times less than a bike. Without a doubt, the bike used less energy than the bicycle, but the bicycle helps us stay healthy and fit.

We are all aware of the rising cost of fuel and how quickly it is rising, making it impossible for everyone to use the services that depend on fuel. In such a situation, the folding bicycle is really helpful because it not only conserves gasoline but also keeps you healthy and doesn't interfere with the task that we will finish by using other forms of transportation, like the bike.

In addition to its advantages of being lightweight, more flexible, and smaller, folding bicycles also offer the added benefit of being able to go through subways and metros. Due to their tiny size, consumers can keep these cycles inside their homes. In the approaching years, it is anticipated that consumer awareness of environmental pollution, exercise, and personal health would enhance the usefulness of the foldable bicycle.

However, the bulk of urban residents deal with traffic-related issues on a regular basis. Customers are anticipated to be forced to purchase foldable bicycles in order to travel within the city limits promptly and safely due to long car lines and hours spent in traffic jams. In order to reduce pollution, governments and private organizations have been urging people to use these foldable bicycles as their main form of transportation. Additionally, the national government have been spending money on developing distinct riding routes and putting legislation into effect that can ensure rider safety [5].

Bicycle And Sustainable Development Goals

In order to accomplish the Sustainable Development Goals, mobility is a crucial component of development plans (SDGs). In order to help cities decouple population expansion from rising emissions and to enhance air quality and road safety, it is still essential to address the requirements of cyclists.

Cycling is a cost-effective and straightforward means of transportation that provides access to employment, markets, schools, and community events in both urban and rural regions.

The bicycle often serves as the only technologically feasible form of cheap transportation for both people and products, which enables individuals to reduce the cost of household transportation. For people who would otherwise have to walk to work, cycling can more than reduce their commute time and increase their access to job prospects, schools, marketplaces, and communities. Additionally, there is a significant likelihood that jobs associated to cycling will lead to economic growth. Cycling investments present excellent chances for sound national, regional, and global poverty-reduction strategies [5].

For many small-scale food producers, cycling is crucial. It can offer safe, egalitarian access to land, resources, markets, knowledge centres, financial services, and non-farm work opportunities. Cycling contributes to year-round food access, especially for the poor. Cycling guarantees improved access to food markets and communities, increases nutrition alternatives, and assures the sustainable delivery of food goods by enlarging the region accessible to people who do not have a substitute method of transportation.

Healthy, non-air-polluting lifestyles are produced via cycling. Cycling increases physical activity, which lowers the risk of heart disease and other side effects of sedentary lives. Cycling can be used in place of individual motorized transportation to enhance air quality and road safety. By making cycling safe, we can lessen the number of people killed and injured in traffic accidents worldwide.

Cycling is a suitable alternative for the first and last kilometres when combined with public transportation and logistics systems, since it leverages renewable human power in the most effective way to move people and products. E-cycling also provides access to the usage of very efficient e-mobility technologies. People have access to an economical and energy-efficient means of transportation when the conditions are favourable for cycling.

Cycling makes it possible for people to transition from using personal motor vehicles to a combination of active transportation (walking and cycling) and public transportation. extra persons Governments will find it simpler to create resilient infrastructure and sustainable transportation systems with an emphasis on affordable and fair access for all if people cycle more frequently [6].

Because cycling is accessible, inexpensive, nonpolluting, healthy, and supports a sustainable economy, it makes cities and human settlements more inclusive, safe, resilient, and sustainable.

On the one hand, it is highly resilient because it is essentially independent from sophisticated high-tech technologies. Modern communication and e-cycling technologies, however, include cycling into cities' Intelligent Transportation Systems. The more walking, bicycling, and public transportation are used, the more sustainable the transportation system is.

The bicycle is a symbol for decarbonizing transport and societies, it offers the possibility for immediate climate action Governments at all levels can take action by integrating cycling into their climate action policies, strategies, education and awareness-raising [6].

DESIGN METHODOLOGY

Phases of Research

An easily transportable bicycle is meticulously designed. Here is a thorough breakdown of each stage [7-12].

Step 1: Review of the input

The first stage is to analyse the daily issues encountered and select a project to serve as a remedy.

Step 2: Selection

Selection as per research interest, group discussion and review of the Literatures.

Step 3 Experimentation and modification of the existing bicycles.

Step 4: Choosing the material and geometry

Modification into foldable bicycle by introducing some additional components in existing bicycle.

Step 4: Create a computer-aided design (CAD) model of the bicycle.

With the help of the measurement and calculated data, a CAD model of the suggested bicycle is produced.

Step 6: Structural study of the CAD model

By using the analysis software, ANSYS, the final CAD model of the bicycle is structurally checked for component failure.
Step 7: Gathered some resources
To build a foldable bicycle, certain items are purchased from the market.
Step 8: The creation stage
Bicycles are manufactured using the finished design.

DESIGN AND ANALYSIS

3D Model of Foldable Bicycle

Solidworks software was utilized to build the geometry (3D model) is one of the CAD (Computer Aided Design) programmer for 3D part modelling for mechanical design. The popular mechanical design automation software Solidworks enables designers to swiftly sketch out concepts, play with features and measurements, and create models and in-depth drawings.

Solidworks is an intuitive piece of software that makes it simple to construct geometry of foldable vehicle. The mechanical engineering and design fields make extensive use of this 3D modelling CAD software.

FIGURE 1. Front and side view of bicycle

FIGURE 2. Front and side view of folded bicycle

TABLE 1: Analysis Using Ansys

Parameters	Value
Total Deformation	0.02268 mm
Equivalent Elastic Strain	0.0036036
Equivalent Stress	496.69 MPa

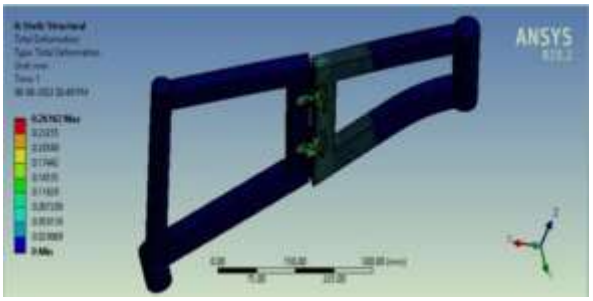

FIGURE 3. Total Deformation

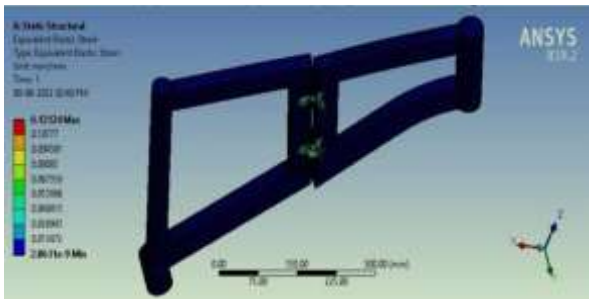

FIGURE 4. Equivalent Elastic Strain

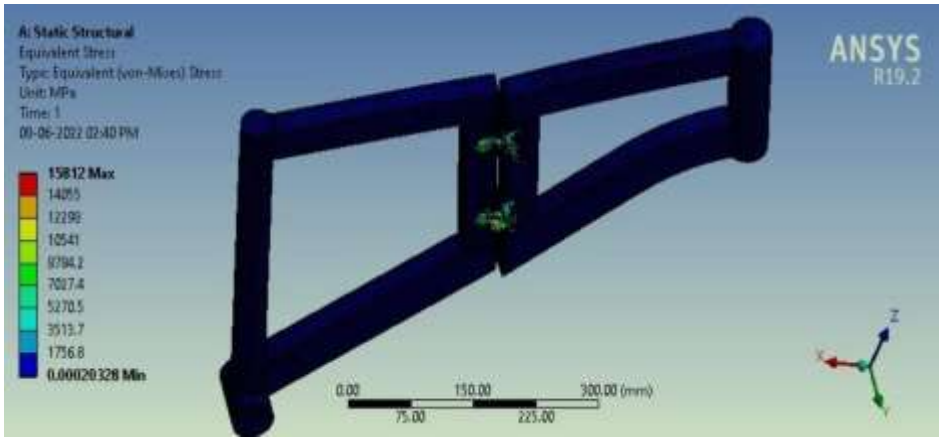

FIGURE 5. Equivalent Stress

FABRICATION OF THE FOLDABLE BICYCLE

Our project's main component is a bicycle frame; thus, it needs to be strong, stiff, and light, which it does by combining different materials and designs. Large pieces of iron known as "iron rods" are frequently utilised in significant construction projects. Iron rods known as rebar are used to join reinforced concrete to strengthen the force (produce tension). You can get a corrugated arrangement (design) with or without an iron bar (rod). A clamp is a type of fastener used to apply pressure from the inside to tightly hold or secure things together in order to prevent movement or separation. A push-pull toggle handle drives the clamp's plunger in and out along its axis and is simple to use. You can use almost all of these pull push toggle clamps as push or pull clamps because they can be locked in two positions. The hinge is a crucial component of the frame that needs close attention. A load-bearing part is the hinge.

A hinge is a mechanical bearing that joins two solid objects while typically permitting only a small amount of rotation. An ideal hinge allows two objects to pivot about a fixed axis of rotation. Hinges can be constructed from flexible material or from moving parts.

FIGURE 6. Bicycle

FIGURE 7. Folded Bicycle

FIGURE 8. Clamp

FIGURE 9. Steel Rod

ADVANTAGES AND LIMITATIONS

Advantages

Intermodally: Intermodally is the first benefit that folding bicycles provide. Folding bicycles can be used in conjunction with other modes of transportation considerably more simply than traditional bicycles. For those who must travel a great distance to get where they are going, this quality is extremely helpful. When you arrive at your destination, you can put together your bicycle and ride it from your house to the nearest public transportation hub. Few cities currently have the necessary infrastructure in place to accommodate bicycle transportation on public transportation.

Retrench of space: Half as much space is needed to keep a foldable bike as a regular one. They are simple to stow in any nook. They are especially helpful for those who live in apartments or do not have a sufficient location to store their bicycles in their workplace due to their ability to fold. You fold it and set it on your desk's side.

Less robbable: You can carry them wherever because they don't take up a lot of room. Don't bother hanging the bicycle outside your business, eatery, museum, or theatre. While some bikes are more portable than others, all of them are sufficient for carrying around.

Easy to travel with them: As we just saw, a foldable bike may be transported anywhere, including as part of your luggage when travelling. One of the reasons I enjoy folding is because of this. Bicycling is considered to be one of the greatest methods to explore a city. No of the mode of transportation—by air, sea, or land—I never leave home without my folding bike.

They lose worth less than a typical bike: Most folding bicycles continue to sell for a fair price. Of course, provided they have received the right care and use. Depending on the mechanical and aesthetic condition you are in, you can sell a folding bike nearly in the same condition that you purchased it.

Limitations

Increased sensitivity to road imperfections: The folding of small wheels is this drawback. These bicycles often have 16 to 20 inch wheels. Smaller wheels have the drawback of making road imperfections more noticeable. This is because it will be more challenging for a wheel to "roll" over barriers and road irregularities the smaller its diameter. The majority of folding bicycles are made for city use. However, you can buy mountain bikes that are the standard size if you like to ride in the mountains.

Difficulty to customize: Comparatively, folding bicycles are far less common than other styles. As a result, customization is a little more challenging because it is more challenging to acquire the appropriate accessories. The good news is that folding bicycles are progressively gaining popularity, and we can always find a wider selection and variety of specialist folding equipment. Distributors who focus on foldable bikes are included. Additionally, you may locate practically any item online and order it from another country owing to the internet.

Little portability of some models: Folding come in a variety of sizes and folding methods. Accept the fact that not all models can be folded and moved with ease. Either they are overly heavy, uncomfortable in their folded state, or folding them up is nearly difficult. When looking for a folding one, it is best to prioritise potability if intramodality is one of your goals. Finding a bike that is portable both folded and unrolled is the key!

They are more expensive than their premiums: Bicycles that fold up are typically more expensive than regular bikes. This is caused, in large part, by the fact that many of the components are made specifically for one kind of bicycle. The cost of production is lower for conventional bikes since they employ parts with standard measurements. It is very likely that you may purchase a conventional bicycle of better range for the same price if you compare the features of a conventional bike with those of a folding one (number of speeds, material, components, etc.).

You must, however, consider what your actual needs are. Perhaps the ability to fold your bike and transport it wherever you go adds a lot of value and makes the purchase worthwhile.

They attract more attention than you're looking for: Anyone who sees you pass by will definitely be intrigued by your strange-looking bicycle and short wheels. There won't be a scarcity of people who approach you as you approach a traffic signal to inquire about your bike. Do those wheels not make you tired? Do they disarm themselves first? What will the price be? are only a few of the most typical queries. Maybe a foldable one isn't for you if you don't like getting so much attention.

CONCLUSION

The design and analysis of the foldable bicycle are successful. Creating a lower body external skeletal structure to support sitting and partially standing posture is the goal of this project. Foldable Bicycle's solid work is done for a 3D model. Using Ansys to determine total deformation, Ansys Workbench is a general-purpose Finite Element Analysis (FEA) programme used on CAD models. Analysis is done on total deformation, equivalent elastic strain, and equivalent stress. The design will be made lighter in the future, and high-quality materials will be used to reduce weight while increasing strength. The design must be put into practise, tested in a real-world setting, and its usefulness in routine situations must be established.

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