DESIGN AND ANALYSIS OF ELECTRIC BIKE WITH SEAT EXPANSION CAPABILITY- A DESIGN REPORT

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Abstract - *Electric bikes are plug-in electric vehicles with two wheels that can be recharged from any external source of electricity, and the electricity is stored in a rechargeable battery, which provides power to one or more electric motors to attain movement. Electric bike, as differentiated from bikes, do not have a step-through frame. The electricity generated from an external source helps in acceleration of the motorcycle. The speed of this cycle is limited (45km/h). The electricity is stored using a battery and the locomotion and movement of the vehicle is hence propelled using an electric hub motor. The electric bike is not using an engine, becomes an effective way of road transport as it causes no pollution. It is eco-friendly and it definitely reduces human effort.*

In this project report, The Electric bike parts such as chassis, front fork, wheels, battery, motor, Electric actuator, guide mechanism etc. are modeled and assembled in a 3D cad tool called SOLIDWORKS. The seat Expansion set up has been added in order to accommodate another rider sufficiently. The structural analysis is carried out using SOLIDWORKS SIMULATION tool. By comparing the results, the Malleable cast iron has yielded less stresses and less displacement compared to 6061-aluminum and S-glass epoxy materials.

Key Words: electric bike, seat expansion, analysis, chassis, assembly, front fork.

1. INTRODUCTION:

Project Electric Bike was chosen in this engineering design project. The initial problem for designing this project which is to design the product that wasn't similar to the current market and ensure comfortable, safety in every aspect. Following points have been considered in designing of this e-bike

-A bike which has seat expansion mechanism

-Easy to use

-reduced weight

-A product which safe to use

-Affordable

We have chosen electric bike for implementing the seat expanding mechanism as it could result in ecofriendly, light weight, easily accessible purposes. A thorough study of electric bike was done by referring various sources, practical studies etc.

Design of an electric bike has been done using SOLIDWORKS. Various parts like front fork, chassis, wheels, seating arrangement etc. have been designed and assembled in a proper way to result an e-bike.

We performed analysis on the modeled e-bike to check whether it could withstand any stresses, loads etc. SOLIDWORKS SIMULATION has been used for performing analysis.

2. MODELING OF AN ELECTRIC BIKE:

This model of electric bike has divided by three sections which are front, middle and rear. The reason of choosing these 3 parts of the bike because of the front fork, frame and swing arm are the crucial part. These crucial parts are connection of weight of the rider and contact surface of road. In order to avoid any catastrophic failure electric bike. So, these parts were important to analysis and simulation.

1. FRONT FORK:

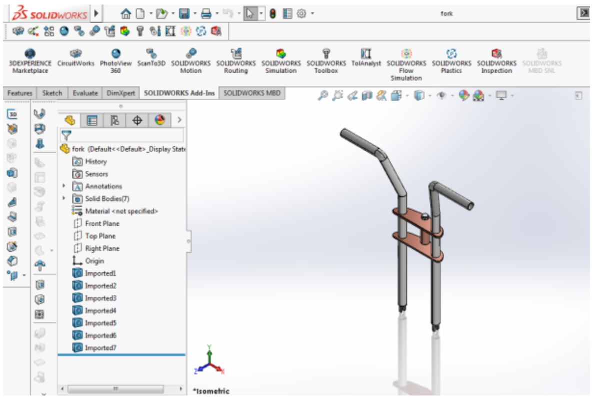


Figure 1: front fork(isometric view)

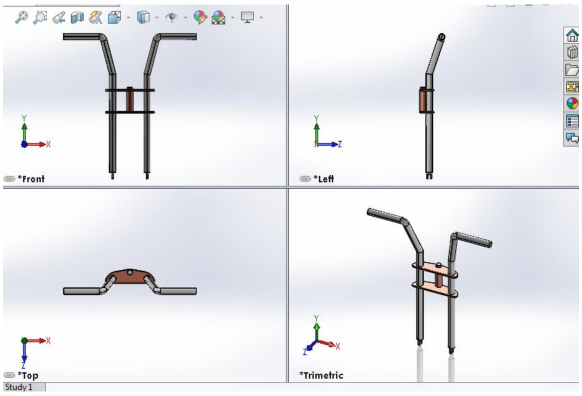


Figure 1.1: front fork (different views)

2. CHASSIS:

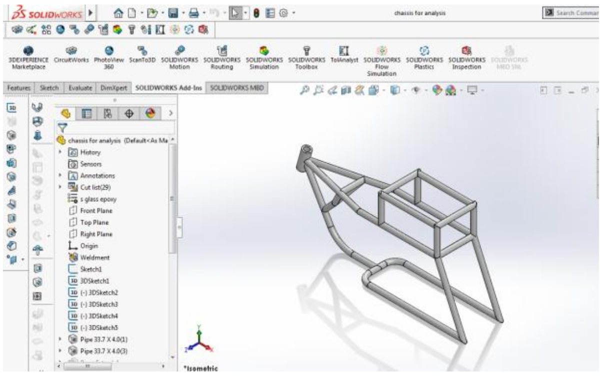


Figure 2: chassis (isometric view)

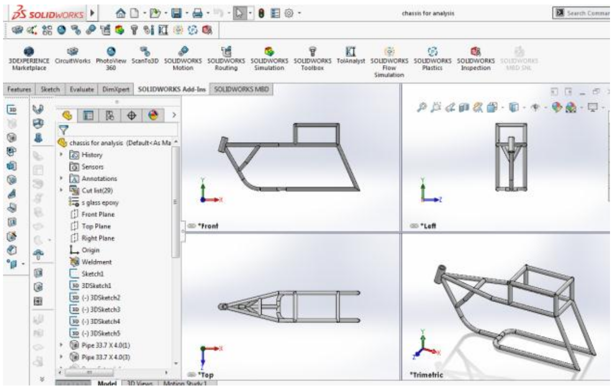


Figure 2.2: chassis (different views)

3. WHEEL WITH DISC BRAKE:

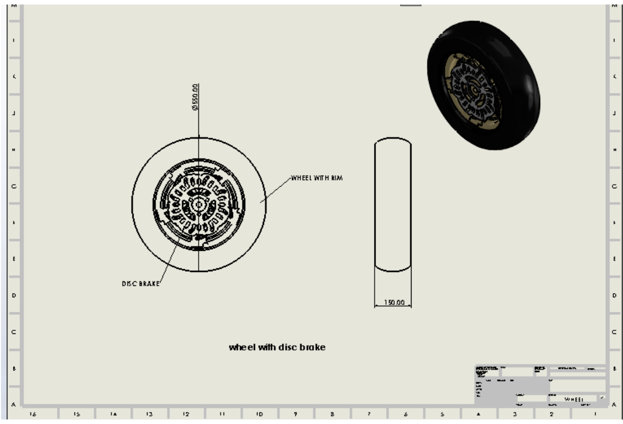


Figure 3: wheel with disc brake (sheet format)

4. BATTERY:

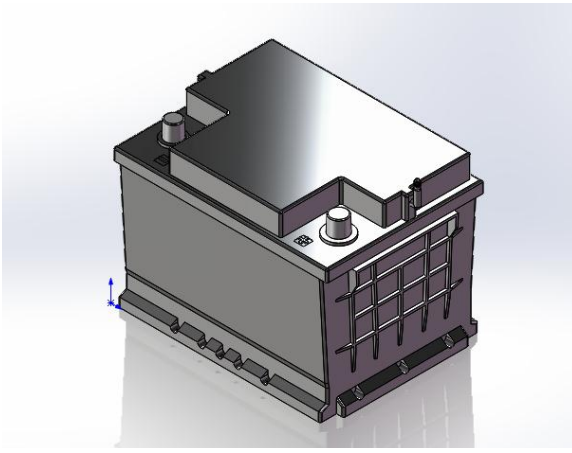


Figure 4: battery (isometric view)

5. HUB MOTOR:

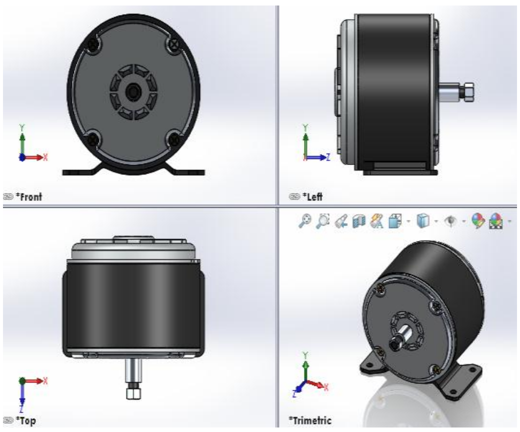


Figure 5: hub motor (different views)

6. CHAIN DRIVE SYSTEM:

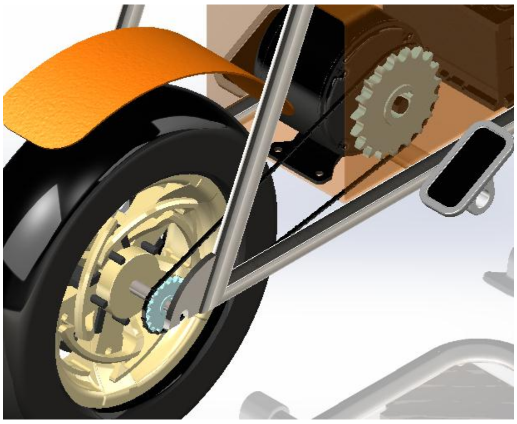


Figure 6: chain drive (isometric view)

7. SEAT:

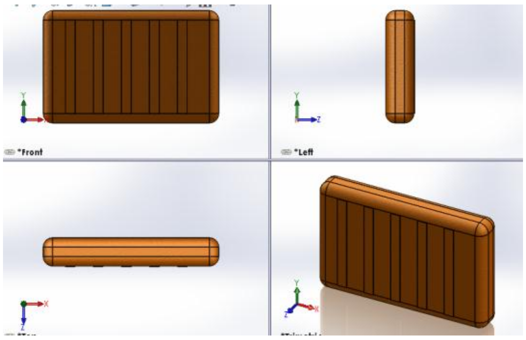


Figure 7: seat (different views)

8. SECONDARY SEAT ASSEMBLY:

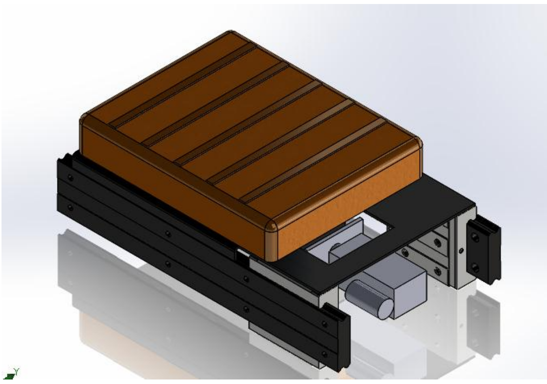


Figure 8: secondary seat assembly (isometric view)

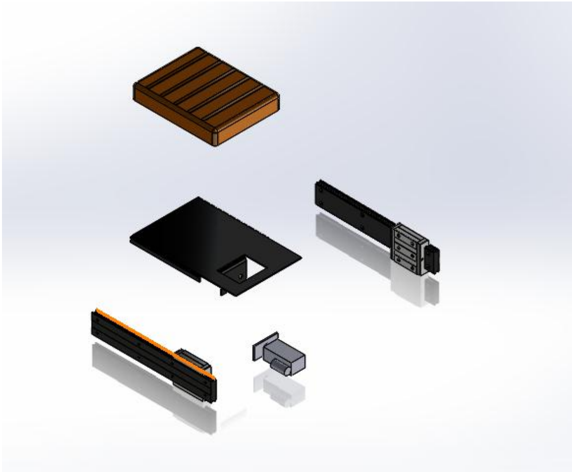


Figure 8.1: secondary seat assembly parts

2.1: ASSEMBLY OF E-BIKE:

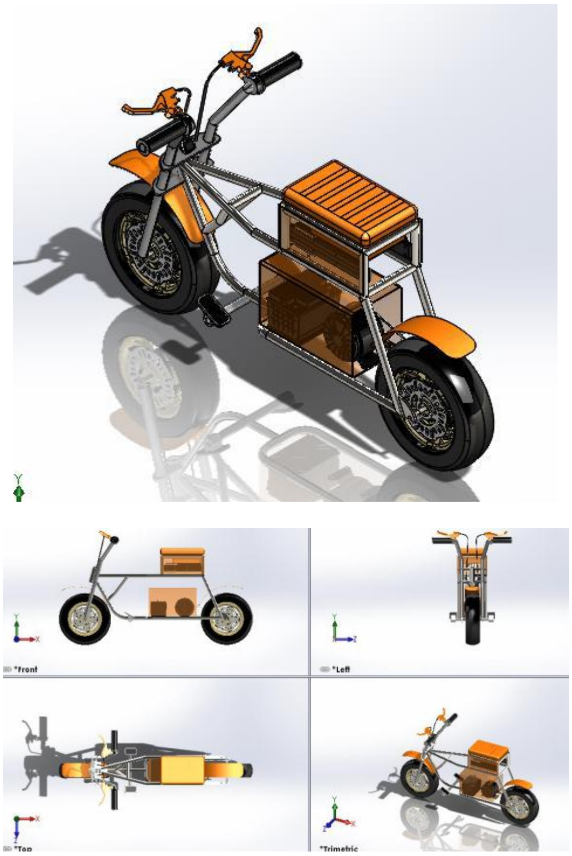


Figure 2.1.1: assembly of e-bike (different views)

2.2: SEAT EXPANSION:

figure 2.2: seat expansion (isometric view)

2.3 DESIGNING OF AN E-BIKE:

Here we have used permanent magnet self-generating motor with 250-watt power and 2100rpm. The motor runs on 48volts and 7.5amps power source. This motor can reach a peak current during starting equal to 15 amps.

P = 2 x 3.14 x N x T /60

250 = 2 x 3.14 x 2100 x T /60

T = 1.13 N m = 1136 N-mm

Reduction in chain drive

R chain = 66/11 = 6:1

Torque at wheel shaft = T x R chain = 1136 x 6 = 6820 N mm

Speed of wheel shaft = 2100 /6 = 350 rpm

Shaft design:

T = 36000 N mm

$T = 3.14 / 16 \times \sigma_s \times d^3$

Fs allowable = 80 N/mm ^{2}

$6820 = 3.14 \times \sigma_s \times d^3/16$

$\sigma_s = 34.73$ N/mm ^{2}

Material = C 45 (mild steel)

$\sigma_{ut} = 320$ N/mm ^{2} ------------ design data book.

factor of safety = 2

$\sigma_t = \sigma_b = \sigma_{ut}$ / fos = 320/2 = 160 N/mm ^{2}

$\sigma_s = 0.5\ \sigma_t = 0.5 \times 160 = 80$ N/mm ^{2}

σ_s is less then allowable so our shaft design is safe.

Design of Sprocket and Chain for Electric Bike:

transmission ratio = Z2 / Z1 = 66/11 = 6. For the above transmission ratio number of teeth on pinion and the number of teeth sprocket is in the range of 21 to 10, so we have to select number of teeth on pinion sprocket as 11 teeth. So, Z1 = 11 teeth.

SELECTION OF PITCH OF SPROCKET:

The pitch is decided on the basis of RPM of sprocket. RPM of pinion sprocket is variable in normal condition it is = 2100 rpm. For this rpm value we select pitch of sprocket as 6.35mm from table.

CALCULATION OF MINIMUM CENTER DISTANCE BETWEEN SPROCKETS:

Dia. of small sprocket,

Periphery = π × dia. Of sprocket

11 × 6.25 = π × D

D = 11 × 6.25 / π ,D = 21.8 mm

Dia. of sprocket,

Periphery = π × dia. Of sprocket

66 × 6.25 = π × D

D = 66 × 6.25/ π ,D = 131.3 mm

So, from table, referred from Design Data book

The minimum centre distance between the two sprocket = C' + (80 to 150 mm)

Where C' = (Dc1 + Dc2) / 2 ; C' = (131.3 + 21.8) / 2

C' = 76.5 mm, minimum center distance = 76.5 + (30 to 150 mm) = 170 mm

CALCULATION OF ALLOWABLE BEARING STRESS:

For pitch = 6.35 & speed of rotation of small sprocket = 2100 rpm. Allowable Bearing stress in the system = 2.87kg / cm ^{2} =2.87 * 981/100 =28 N /mm ^{2}

CALCULATING MAXIMUM TENSION ON CHAIN:

Maximum torque on shaft = $T_{max} = T_2 = 6820$ N-mm

T1 = Tension in tight side

T2 = Tension in slack side

O1, O2 = center distance between two shafts

$\sin \propto = R1 - R2 \ / \ O1O2$

$\sin \propto = 65.65 - 10.9 \ / \ 170$; $\sin \propto = 0.33$; $\propto = 18.78$

$\theta = (180 - 2\propto) \times 3.14/180$; $\theta = (180 - 2*18.78) \times 3.14/180$; $\theta = 2.48$ rad

According to this relation,

$T1/T2 = e^{\mu\theta}$

$T1/T2 = e^{0.35 \times 2.48}$; $T1 = 2.38\ T2$

We have, $T = (T1 - T2) \times R$

$6820 = (2.38\ T2 - T2) \times 65.65$; $T2 = 75.27$ N

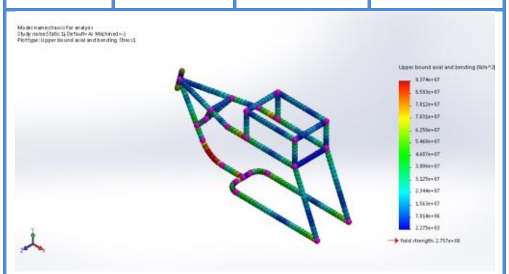
$T1 = 2.38 \times 75.27$ $T1 = 179.16$ N

3. STRUCTURAL ANALYSIS OF CHASSIS:

Structural analysis and design are a very old art and is known to human beings since early civilizations. The main purpose of any structure is to support the loads coming on it by properly transferring them to the foundation. The main aim was to reduce the weight, centralize the weight and lower the weight of the frame. Thus, the metal tubes were divided into primary, secondary and tertiary members based on the tube diameters and thicknesses in order to reduce the overall weight of the frame without affecting its strength. The Centre of gravity of the frame is below the rider seating area thus ensuring a low and centralized frame weight. The trusses not only provide strength and rigidity but also safety of the driver and essential vehicle components against impacts.

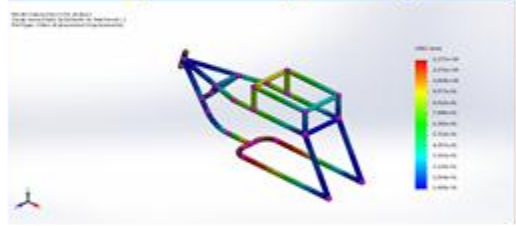
3.1. STRUCTURAL ANALYSIS OF CHASSIS USING CAST IRON MATERIAL:

Name	Type	Min	Max
Stress1	Upper bound axial and bending	0.000e+00 N/m^2 Element: 364	9.374e+07 N/m^2 Element: 86



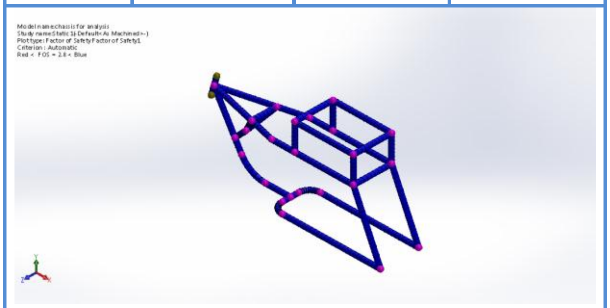
study results-stress

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+00 mm Node: 91	1.277e+00 mm Node: 177



study results- displacement

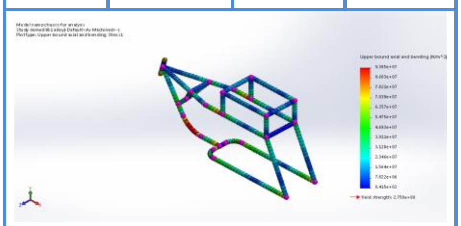
Name	Type	Min	Max
Factor of Safety1	Automatic	2.941e+00 Node: 94	1.212e+05 Node: 85



study results-factor of safety

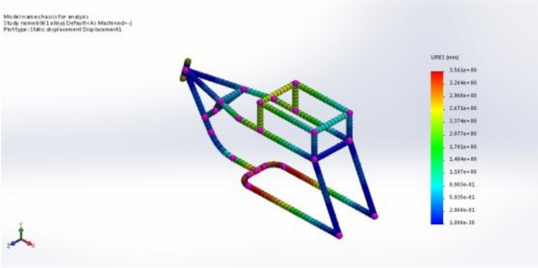
3.2. STRUCTURAL ANALYSIS OF CHASSIS USING 6061 ALUMINIUM MATERIAL:

Name	Type	Min	Max
Stress1	Upper bound axial and bending	0.000e+00 N/m^2 Element: 364	9.385e+07 N/m^2 Element: 86



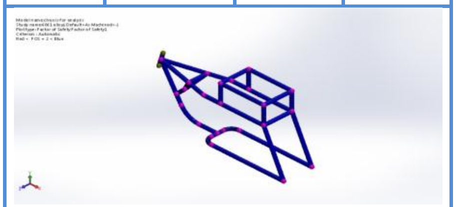
study results-stress

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+00 mm Node: 91	3.561e+00 mm Node: 177



study results-displacement

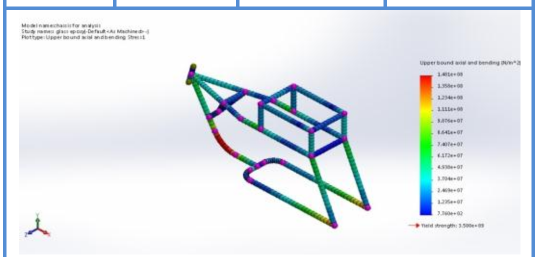
Name	Type	Min	Max
Factor of Safety1	Automatic	2.930e+00 Node: 94	3.268e+05 Node: 85



study of results-factor of safety

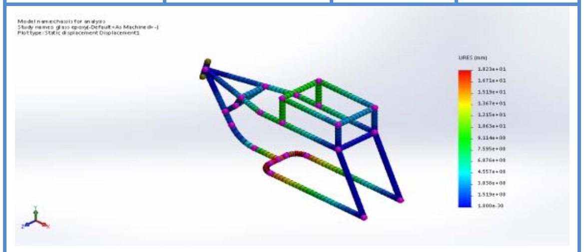
3.3. STRCTURAL ANALYSIS OF CHASSIS USING S-GLASS EPOXY COMPOSITE MATERIAL:

Name	Type	Min	Max
Stress1	Upper bound axial and bending	0.000e+00 N/m^2 Element: 364	1.481e+08 N/m^2 Element: 87



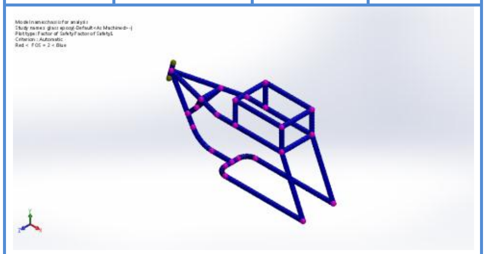
study results-stress

Name	Type	Min	Max
Displacement1	URES: Resultant Displacement	0.000e+00 mm Node: 91	1.823e+01 mm Node: 103



study results-displacement

Name	Type	Min	Max
Factor of Safety1	Automatic	2.363e+01 Node: 95	4.510e+06 Node: 85



Study results-factor of safety

4. RESULTS AND DISCUSSIONS:

The chassis has been structurally analyzed using 6061-alloy, S-glass epoxy and malleable cast iron materials. The results are as follows:

S.NO	MATERIAL NAME	VON MISSES STRESSES [Mpa]	RESULTANT DISPLACEMENT[MM]
1	MALLEABLE CAST IRON	93.74	1.277e+00
2	6061 ALLOY	93.85	3.561e+00
3	S-GLASS EPOXY	148.1	1.823e+01

By comparing the results above the Malleable cast iron has yielded less stresses compared to 6061 alloy and S-glass epoxy materials. The stresses yielded in malleable cast iron is less than the material yields strength.

5. CONCLUSION:

Due to the many problems of congestion, pollution and urban mobility, new modes of transportation (electric bike) transportation devices, increasingly seem to be an alternative to widespread automobile use. However, electric bike is designed for a broader segment of the population and is meant to meet a wider variety of mobility requirements in urban transfers to alternative forms of mobility and use for short distances. However, this electric bike is targeted more for young people and seems primarily intended for recreational purposes.

6. REFERENCES:

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