An Improved Rickshaw Van with Added Two-Speed Gear, Suspension, and Foot Wooden Brake

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***Abstract*—** The rickshaw van is one of the key modes of transportation in many cities and urban areas that may offer a comparatively comfortable, quiet, and environment-friendly transportation system for urban and rural areas of Bangladesh. The existing rickshaw van had drawbacks in carrying capacity, inadequate brakes, insufficient gearing, smaller width of hubs, lack of suspension, and weak wheels. The primary focus of this research was to develop a rickshaw van at the Farm Machinery and Postharvest Technology Division, Bangladesh Rice Research Institute, Gazipur, Bangladesh for improving its performance and reduce drudgery in transportation without requiring significant changes to the structure of the existing rickshaw van. The traditional rickshaw van was modified with added two-speed changeable gears, modified hubs with enlarged width, two freewheel sprockets, suspension springs, UC pillow block bearing, and wooden foot brake using CADRA engineering drawing tools. Low and high-speed changeable gears were also added to the prototype of the two-speed rickshaw van. Dual freewheel sprockets were added to drive the rear wheels only forward direction to pass any obstacle. The spoke spans of the wheel hubs were enlarged to increase the strength of the spoke of the wheel to bear more shock load which increased the carrying capacity of the prototype. During the performance test, the wheel of the two-speed rickshaw van was damaged with a 500 kg load, while the wheel of the baseline rickshaw van was damaged with a 300 kg load. The safe load of the developed prototype was found to be 350 kg. The performance test revealed that the developed prototype provides satisfactory speed, easier motion control, and good scope for manipulating the shares of human effort. Besides reducing air and sound pollution, such rickshaw vans demanding less physical effort may provide large-scale employment in urban and rural areas of Bangladesh.

***Keywords*—** Rickshaw van, two-speed gear, suspension springs, wooden foot brake.

I. INTRODUCTION

In Bangladesh, rickshaw vans are the most extensively utilized and well-liked mode of transportation for both passengers and products/goods. Bangladesh's urban transportation challenges of mobility, congestion, safety, and environmental elements are becoming more and more crucial (Hoque et al. (2005). Since the poorest populations in Bangladesh cannot afford to pay for transportation services, the majority of people travel by foot. Instead, they must carry heavy burdens over long distances on their backs, shoulders, and heads, including agricultural inputs and outputs, water, and fuel for their homes.

A more contemporary variant of the pushcart, rickshaw vans is particularly common in Bangladesh's cities and metropolitan areas. Rickshaw vehicles are used to transport passengers, goods, and crops (Banglapedia, 2006). In Bangladesh, non-motorized three-wheeler rickshaws are the most popular mode of transportation. When you first leave your house, one or more of these tri-wheelers will ring their bells to attract your attention. According to Rukhsana et al. (2013), the rickshaw van is a very well-liked mode of human-powered transportation that is widely employed in India and many other south-east Asian nations. Passengers, as well as their belongings and cargo, are transported using it. People from low socioeconomic status and the impoverished continue to work pulling cycle rickshaws, which requires them to put in a lot of effort over a lengthy period of time. Their jobs do not have set hours. Anfrage 2002) mentioned that a British firm called "Rickshaw Bremen" created a particular type of rickshaw called the "Rickshaw Van" that can carry specific quantities of cargo. In place of the passenger seat, there is a pickup carriage. It has a load capacity of roughly 100 kg. In Maharashtra, India, the "Nimbkar Agricultural Research Institute (NARI) has built and produced two varieties of rickshaws. They have enhanced pedal rickshaws and pedal rickshaws with motor assistance. The updated pedal rickshaw features three speeds, shorter long chains, back wheel shaft braking, stronger suspension, and less drag from the air. A small permanent magnet motor was fitted to the rickshaws in motor-assisted pedal rickshaws (MAPRA) so that it could help the rickshaws' pedal anytime they were under load or traveling uphill (Rajvanshi, 2002).

In Bangladesh, suburban regions are where pedal-powered rickshaw vans are most popular. The tricycle, which has two wheels at the back and a front wheel with steering capability, is the design configuration that is utilized the most frequently. The frame, which is constructed of thin-walled steel tubing arranged in triangles for strength and alignment, is joined to the main chassis, which is made of a mild steel angle bar. The rickshaw-van wheel is made up of a rim to support the tire, wire spokes pulled tautly, and a ball-bearing hub. Each wheel has 48 spokes, which are positioned tangentially and kept in tension by nipples in the rim that may be changed. The driving sprocket is connected to the driving sprocket by a mechanism. Ziauddin et al., 2009, estimated that the driving sprocket's diameter, circle pitch, and tooth count are anticipated to be 201 mm, 12.70 mm, and 48 mm, respectively. The driven sprocket has 22, 12.70, and 87.63 millimeters in diameter, respectively, and 12.70 millimeters in circular pitch. It has a platform constructed of wood where a rickshaw driver maintains cargo or other items for travel. The pedal-crank movement is what transfers the driving force to the rear axle via the chain and sprocket arrangement. Human muscle movement provides the power for the pedal-driven cycle rickshaw. The conventional rickshaw, or "man-powered vehicle," is a type of vehicle that includes these cycle-rickshaws. According to Gallagher (1992), the name was originally given to the hand-pulled rickshaws which thronged Asian cities in the 1920s and 1930s, but now it applies to the cycle rickshaws of India and Bangladesh as well. These vehicles are also known as trishaws, pedicabs, samlors, xiclos, or becaks.

The NMPT dealt with in this research paper include cycle-rickshaw having one front wheel and two rear wheels, an average speed of 5 to 12 km/hr over distances of up to 40 km, and capable of carrying two passengers in addition to the driver, or freight loads of up to 250 kg without a passenger (Replogle 1992). Since the rickshaw only has front brakes, the braking system is equally subpar.

So, when traveling downhill at high speeds, abrupt stopping creates a catapult effect that causes the rickshaw to overturn. (Rajvanshi, 2002).

When we compare additional walking time, waiting time, and transfer penalties associated with motorized vehicles for short trip excursions, the major complaint of the rickshaw as a slow-speed congestion-generating vehicle is advantageously traded off (Bari & Efroymson, 2004). Today's poor and ill-health rickshaw drivers cannot use the regularly used design of the rickshaw van as mentioned above. A growing number of teenage males have also been seen working as rickshaw pullers to help support their families. They appear to struggle to draw the current rickshaw, which is bad for their health (Ziauddin et al., 2004). In Bangladesh's rural areas, many individuals pass away due to delayed hospitalization. Due to the lack of decent roads, it is challenging for contemporary cars to go on the village roads, therefore the villagers primarily rely on manually-driven rickshaw vans or occasionally boats to carry patients.

These modes of transportation are extremely slow, especially when it comes to saving a life. (Pronob et al., 2019). Therefore, the existing rickshaw van needs to be redesigned for ease of pulling, carrying more loads, increased speed, more comfortable, and ease of braking. Hence an attempt has been undertaken to improve the rickshaw van with the following objectives.

Objectives:

- To modify the existing manual rickshaw van to enhance labor productivity.
- To reduce drudgery in farming and transportation of goods.

II. MATERIALS AND METHODS

The study was conducted at the Farm machinery and Postharvest Technology (FMPHT) divisional research workshop of the Bangladesh Rice Research Institute (BRRI), Gazipur, Bangladesh.

The performance of the rickshaw van was evaluated in the divisional workshop and the farmer's village of Dhirasram, Gazipur. The opinions of farmers were used to design and develop a manual carrier, in terms of their wishes regarding a manual carrier.

To accomplish this, a questionnaire field survey was conducted to collect the opinions of farmers regarding manual carriers.

A baseline test program was done at the FMPHT division in BRRI, Gazipur on the existing rickshaw van to identify problems. The test program was conducted to measure the following parameters

- Weight distribution (change of height, cm);
- Deflection of the tire (mm);
- Speed with freight and trolley drivers (km/hr);
- Pulling force (kg);
- Pedal revolution (rpm);
- Pedal force (kg);
- Deflection of the axle shaft (mm);
- Drop test (Vertical and inclined).


(a) (b)


(c) (d)

Photo 1: Test of an existing rickshaw van

Problem identifications of the existing manual carrier: The rickshaw vans are mainly used to carry goods; they are often used to transport people as well and can carry 6-8 persons. It could not carry more loads. The carrying capacity of the trolley was low. The wheel became damaged when it carries more than a 300 kg load (Photo 2). Existing rickshaw vans had no desire for speed change gear and gear change lever (Photo 3). Sufficient gearing was needed to drive at the desired speed. Driving on a sloping road with a heavy load was very difficult. The brakes of the trolley were poor and inadequate (Photo 4). A high-capacity foot brake was needed to stop the rickshaw vans in any emergency condition. The road condition in Bangladesh is not good. Due to the lack of suspension, it could not carry more weight (Photo 5). Suspensions were needed to make the drive and transportation easier and more comfortable. The width of the spoke span was small to carry more weight (Photo 6). Enlarged spoke span was needed to increase the carrying capacity. The rickshaw vans' designs have insufficient gearing, poor steering geometry, smaller width of hubs, lack of suspension, small diameter of the shaft, weak wheels, and inadequate brakes.

Photo 2: Damage wheel for heavy load

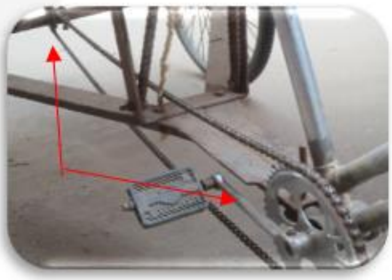

Photo 3: Insufficient gear

Photo 4: Inadequate brakes

Photo 5: Platform support without suspension

Design considerations of the manual carrier (rickshaw van): Improvements were made in the area of chain, gear, speed change mechanism, brake system, wheel hubs, steel wheel, front axle, pedal sprocket, and suspension of the manual carrier. The design was completed using the following design considerations:

- Ease of speed change;
- Higher loading capacity;
- Ease of operations;
- Ease of emergency braking system;
- Ease of transportation of agricultural goods and other freights.

The traditional trolley (rickshaw van) was used to design and develop the prototype of the manual carrier. After testing, the result was analyzed to consider the design of a manual carrier. Then, the engineering design of the manual carrier was carried out with the help of CADRA engineering drawing tools. Various parts were purchased from the local market. Manufacturing and assembling were done in the FMPHT division, and the prototypes were tested and the test results analyzed. Ropes, scales, bamboo sticks, stopwatches, balance, wooden bases, wooden blocks, bamboo, measuring tape, height gauge, screw gauge, slide calipers, etc. were also used during the study. The material used: Seat assembly, body assembly, handle assembly, wheel assembly, paddle assembly, GI sheet, MS sheet, MS flat bar, and MS shaft were used to fabricate the prototype of the manual carrier.

III. RESULT AND DISCUSSION

Details of the improved rickshaw van

The design configuration is most commonly used in the van rickshaw, with two wheels at the back and a front wheel with steering action. The driving force is transmitted to the rear axle by the pedal-crank movement through the chain and sprocket system (Photo 7). The power of the pedal-driven rickshaw van is obtained from human muscle action. Fig. 1 shows the schematic diagram and two-speed change mechanisms of the van rickshaw. Standard traditional rickshaw components available in the market were used for fabrication purposes.

Photo 6: Small width of spoke span

The mainframe was fabricated by a mild steel angle bar (Fig. 3&4). Fig.2 shows power trains assemble from a developed rickshaw van. The wheel shaft link and boss sprocket were positioned so that they occupy minimum space (Fig. 5&6). The center of gravity of the vehicle is well within the three-wheel centers. The wheelbase was kept the same as the conventional pedal-powered cycle rickshaws. The suspension system was provided with springs with sufficient damping. A paddle break arm was added to the right side of the driver (Fig. 7). A wooden bar was set into the broken housing which was locked by a bolt (Fig. 8). The position of the driver's seat in the layout was followed to be the same as the conventional cycle rickshaw.

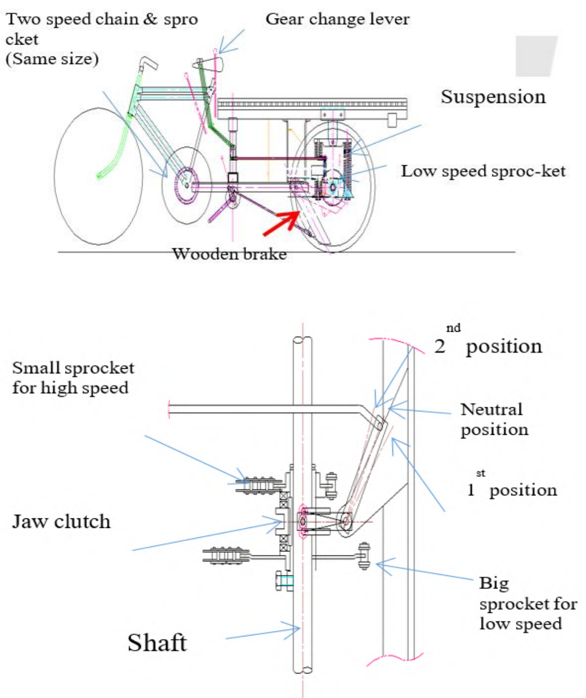

Figure 1: *Schematic diagram and two-speed change mechanisms*

Photo 7: Prototype of rickshaw-van

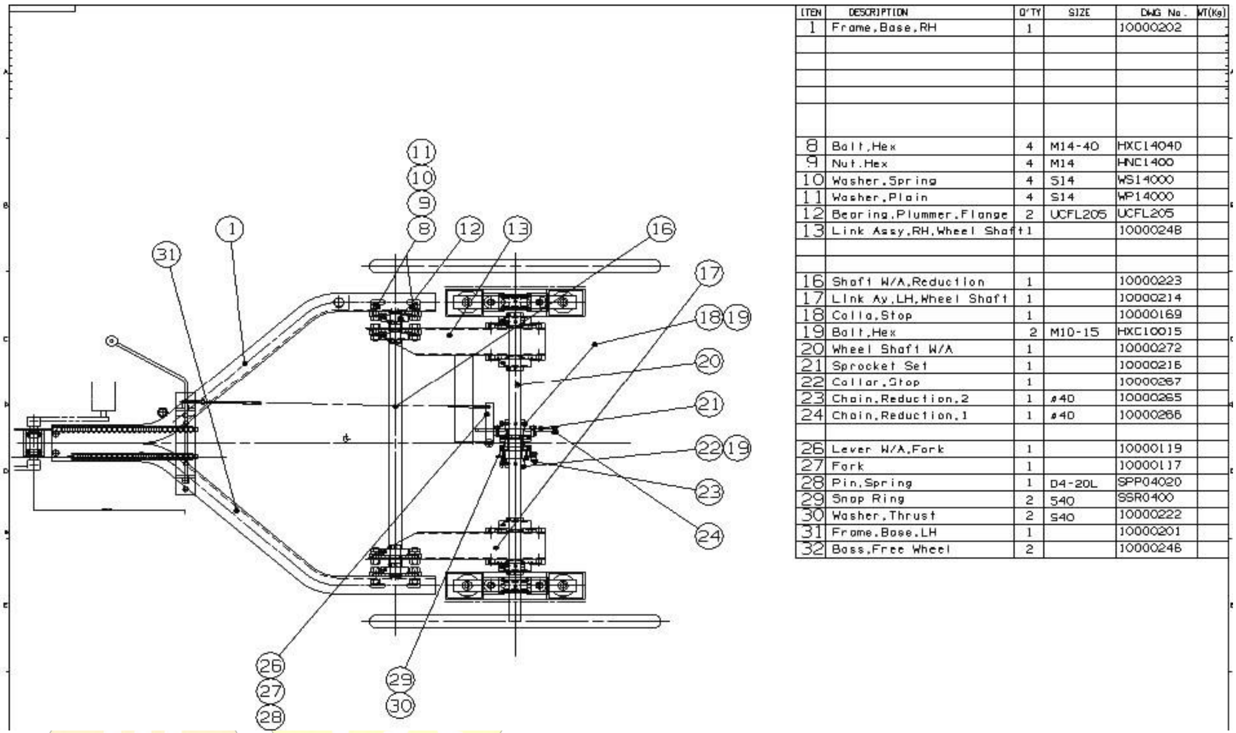

Figure 2: *Power train assemble of rickshaw-van*

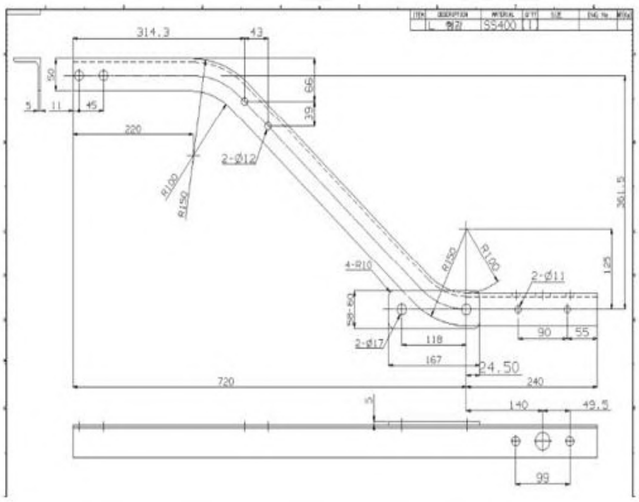

Figure 3: *Left side base frame*

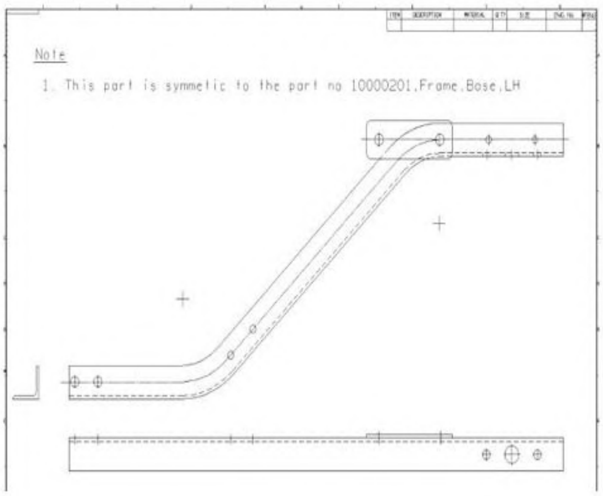

Figure 4: *Right side base frame*

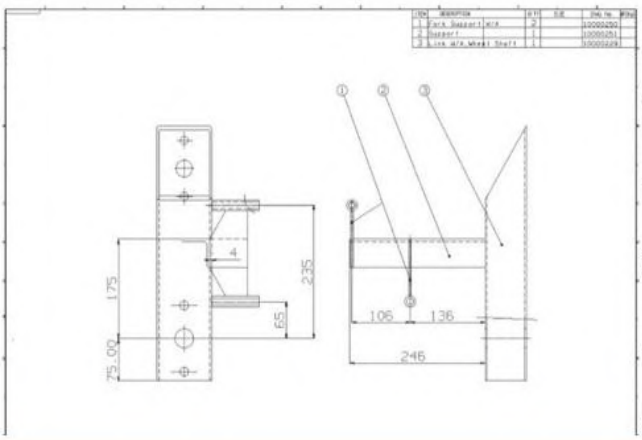

Figure 5: *Wheel shaft link*

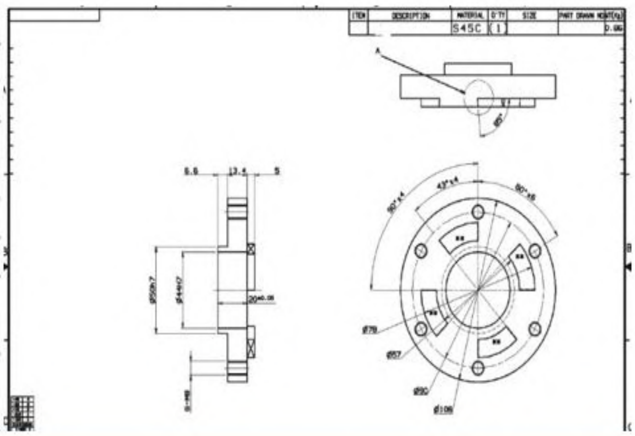

Figure 6: *Boss sprocket*

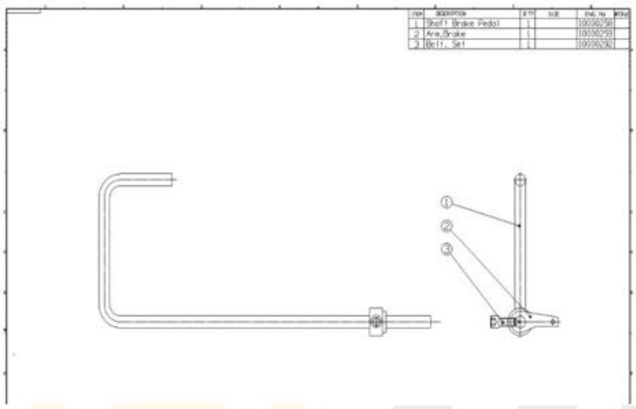

Figure 7: *Paddle break arm*

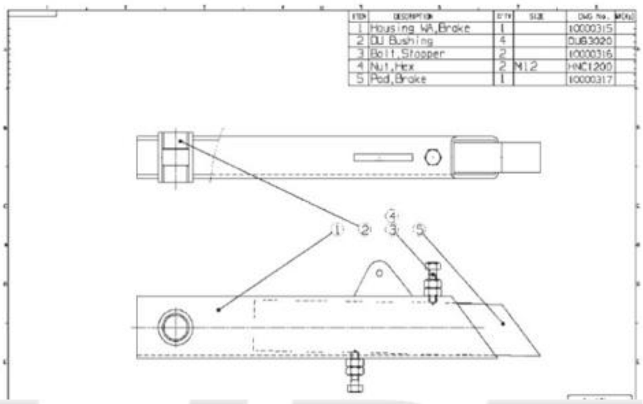

Figure 8: *Break Housing Assemble*

Driving system

Gear: Several gears were added to the prototype of the trolley to achieve a convenient driving speed for carrying small and heavyweights. Two gears were used in the two-speed prototype of the trolley. In the two-speed trolley, the driver could drive the trolley at low and high speeds by using only two gears. The driver could use the first or second gear according to the desired speed (Photo 8).

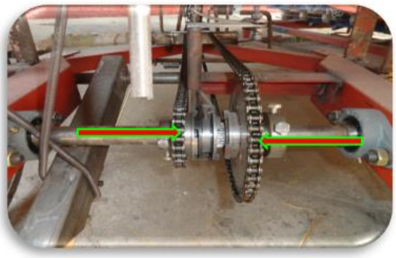

Photo 8. Two-speed gear mechanism

Dual freewheels: Dual freewheel sprockets (Photo 9) were added to the end side of each rear wheel. These freewheel sprockets were used for effective driving. In the existing trolley, one wheel could move in a backward and forward direction and another wheel could move in a forward direction. The added dual freewheel sprocket drives the rear wheels only in a forward direction. It worked like a differential, allowing movement in only one direction. These freewheel sprockets help the trolley to pass any obstacle without difficulty. For increasing the energy absorption range (Increasing deflection limit), they worked appropriately.

Photo 9. Freewheel sprocket

Heavy-duty final drive chain: Heavy-duty chains were used for the transmission of power from the front sprocket to the rear axle. In the 2-speed trolley, heavy-duty drive chains were used to carry heavy weight and provide more effective pedal force from the pedal sprocket (Photo 7).

Gear change lever: Two gear change levers were added to the right side of the driver (Photo 10). The driver can change gears using these levers to drive their desired speed. These levers are jointed with two connecting full-thread rods to change the gears.

Photo 10. Gear change lever

Spoke span: The spoke span of the wheel hubs was enlarged to increase the strength of the spoke of the wheel to absorb more energy. The existing spoke span angle was 9°33´ and the developed spoke span angle was 14° (Photo 11). The strength of the spoke also depends on the tension of the spoke. When the tension is properly retained on the spoke, it can absorb more energy both in static and dynamic load conditions.

The enlarged width of the hubs increased the carrying capacity of the trolley. In the existing hub, the load was only exerted vertically on the wheel, and the hub could not absorb energy properly due to its small width. Damage may occur for this reason. But in the developed hub, the enlarged (Photo 11) width enables it not only to carry the vertical load but also to absorb the axial energy or force.

Photo 11. Enlarged spoke span of the wheel hub

UC (Pillow block) bearing: Pillow block bearing was used to increase the carrying capacity of the van; UCP bearing was used instead of applying two bearings for one wheel and enlarged the diameter of the shaft to increase the carrying capacity of the rickshaw van. UC (Pillow block) bearing (Photo 12) was used to absorb more energy by the rear axle in dynamic load conditions. It can resist oscillating force when the trolley moves on a broken road. When the trolley carries a heavy load, deflection and bending occur on the wheel and rear shaft, respectively. At this time, the UC bearing could carry a heavy load by minimizing shaft bending because it could be inclined slightly.

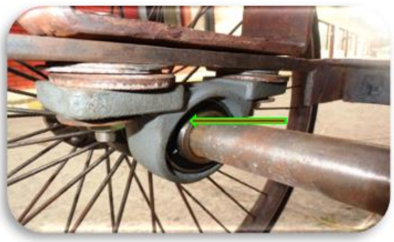

Photo 12. UC pillow block bearing

Spring suspension: Two suspension springs were used in this prototype of the trolley to adjust road conditions and make the drive or transportation easier and more comfortable (Photo 13). This could support more dynamic force and energy in any condition of oscillating movement of the trolley in poor road conditions. In dynamic load conditions, it worked properly to increase the energy absorption range (Increasing Deflection Limit).

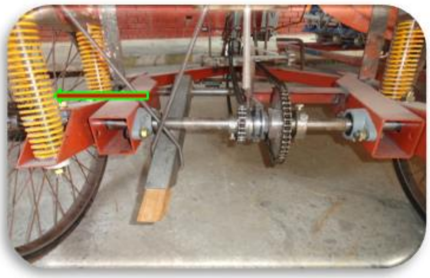

Photo 13. Spring suspension

Safety

Foot emergency wooden brake: To make the trolley safer, one emergency wooden foot brake was introduced in the prototype (Photo 14). In an emergency, the driver can press the foot brake with his right foot to stop the trolley within 3-4 feet immediately.

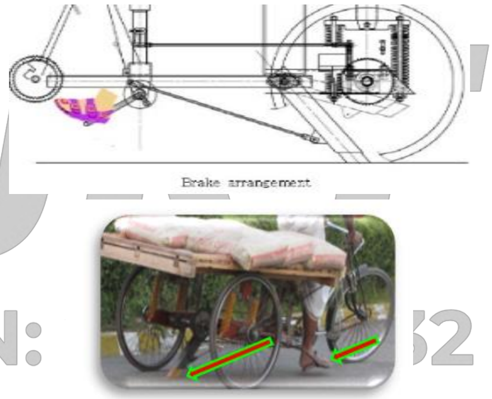

Photo 14. Brake arrangement

Cost

Table 1: *Cost of the developed rickshaw van.*

Equipment	Quantity	Price(Taka)	Price (US$)
Rickshaw type van	1	14,000	164.71
Set of Spring Suspension	2	4,000	47.06
Set of wooden brake	1	2,000	23.53
Gear	2	1,000	11.76
Other Accessories	-	2,000	23.53
Installation and Labor cost	-	2,000	23.53
Total		25,000	294.12

Note: 1 US$ = 85 BD TK.

The cost of the developed van is presented in table 1. The price of the rickshaw van varied with the quality of the materials.

The working life of the rickshaw van was considered five years. The cost of the rickshaw van was 25,000 Tk/ha (294 USD), however, the traditional (rickshaw van) cost was over 14,000 Tk/ha (165 USD).

Observation trials

Operating test: Place an obstacle in front of one wheel and pass it with the conventional and newly developed van to assess the dual freewheel system and the driving speed. Low-speed gear could easily pass obstacles and slope with heavy weight (Photo 15). The driver can change gears for their desired speed by changing the gear lever in high-speed and low-speed gear options.

Photo 15. Operating test of the trolley

Drop test: This test was carried out to assess the strength of the wheel with modified hubs. The carrying load and drop height of the test was 500 kg and 200 mm. Cement bags were used as loading materials for the running drop test (Photo 16).

The wheel of the developed rickshaw van was damaged with a 500 kg load and 200 mm drop height whereas the wheel of the traditional rickshaw van was damaged with a 300 kg load at the same drop height.

During the running drop test, the wheel of the trolley was damaged with a 500 kg load whereas the wheel of the traditional van was damaged with a 300 kg load. The safe loading of the existing trolley was found 240 kg of weight whereas the safe loading of the developed prototype was found 350 kg of weight. About 46% of safe loading capacity increased in the developed prototype regarding the existing rickshaw van.

Photo 16. Drop test of the developed rickshaw van

Speed test: Speed is varied with different load conditions. Here is the speed test, which used a safe load for this developed prototype which was 350 kg. During the speed test, the two-speed type trolley was tested with and without load conditions by a different driver (Table 2). Without load conditions, the speed range was 10-11 km/h and the speed range was found in load conditions 7-8 km/h.

Table 2: *Speed of the van with and without load.*

Observation Trial	**Without Load**			**With Load (350 kg)**		
	Distance (m)	Time (Sec)	Speed, km/h	Distance (m)	Time (Sec)	Speed, km/h
1	200	66	10.91	200	105	6.85
2	200	73	09.86	200	102	7.05
3	200	68	10.59	200	91	7.91
4	200	70	10.28	200	99	7.27
Speed			10-11	Speed		7-8

IV.CONCLUSION

The existing rickshaw van was used to design and develop the improved rickshaw van. The existing rickshaw van had some limitations on carrying capacity, inadequate brakes, insufficient gearing, smaller width of hubs, lack of suspension, and weak wheels. Some new and modified parts were added to increase the carrying capacity, and make driving more convenient and safer. Two speeds trolley can drive at low and high speeds by using only two gears. Modified hubs, two freewheel sprockets, UCP bearings, and suspensions were used to increase the capacity of the van where two-speed gears were used as gear mechanisms to get convenient speed. About 46 % of safe loading capacity increased in the developed prototype. The improved rickshaw van will play an important role in the development of rural life, especially in the rural transport sector. The newly improved rickshaw van is suitable for suburban and rural use. It will increase the transport facility in the rural area in terms of agricultural goods or others carrying facilities. It will reduce the drudgery in farming and transportation of goods as well as increase labor productivity.

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