The Role of Light Railway in Sugarcane Transport in Egypt

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1. Introduction

The first section of the Egyptian standard railway for public transport service started at 1854. Fifteen years later, the first light railway network established to serve sugar industry southern Egypt. A light railway network initiated through the area considered for sugarcane production whenever a modern sugar mill established. The light railway represented the mechanism that continuously convey and feed each sugar factory with raw material of sugarcane produced in wide farm areas around the mill.

As a principle transport system, the light railway networks started transport service simultaneously with the beginning operation of each sugar mill. Whenever a modern sugar mill constructed, a light railway net established for its own cane transport service. The first light railway network started service at the west bank of Nile at 1869 when the first modern sugar mill started operation at Armant (Ar. 691 *km* south Cairo). At 1896 the second oldest light railway was initiates at the west bank of Nile to serve cane transport to Nagaa-Hamadi factory (N. H. 553 *km* south Cairo). At the early stage of the 20^{th} century, two light railway networks started cane transport service in Abo-Qurkas (AQ. 267 *km* south Cairo) in 1904 and in Kom-Ombo (KO. 834 *km* south Cairo) in 1912 when two sugar factories begin operation at these two locations. Other four light railway networks were established within the period from 1963 to 1987 in Edfo (Ed. 776 *km* south Cairo), Quse (Qu. 573 *km* south Cairo), Dishna, (Di. 573 *km* south Cairo) and Gerga (Ge. 502 *km* south Cairo) when the sugar mills started there **(Afifi 1988).**

Based on the data of the annual report of the Sugar Counsel 2010 and former reports, continuous change of the role of narrow railway system has been recorded over the last two decades. Figure 1 shows the development of the light railway system contribution to the transport of vegetative cane delivered as row material to sugar industry. Road transport strongly competes as cane transport mean due to constant improvement of infield roads and the availability of road vehicles. On the other hand, the decline of the narrow railway system contribution may partially refer to the expansion of cane plantations outside the light railway net. The chapter discusses the existing conditions and the expected future of the role of light railway initiated for cane transport in Egypt. Alternative road transport vehicles may replace the narrow railway because of availability in addition to transport cost. It seems like the conditions of narrow railway system of cane transport in Egypt has some similar aspects of that of South Africa as reported by **Abdel-Mawla (2001)**. **Malelane (2000)** concluded that the economics of each cane transport system establish the optimum mix of transport mode in South Africa. The availability of road transport given the limitations of fixed rail siding placement and infield haulage distances.

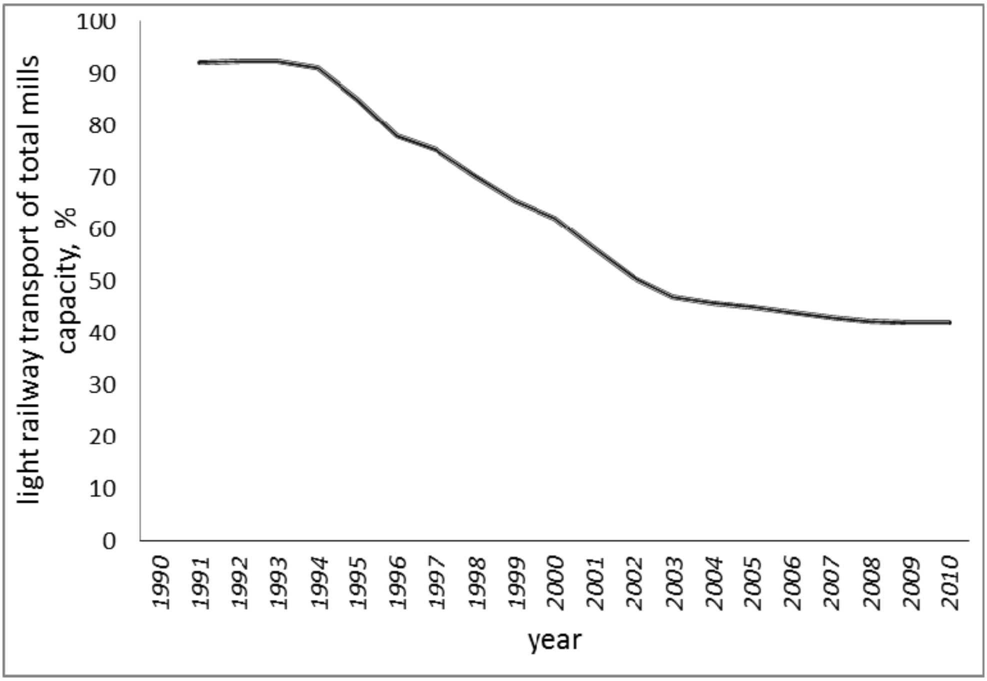

Fig. 1. Development of the role of light railway system for feeding row materials to sugar industry.

2. Light railways line expansion

The narrow railway network and whole stalk wagons represented the principle cane delivery system especially for the old constructed sugar industry. The regions at which the narrow railway expanded for sugarcane transport occupy continuous areas along both sides of the Nile. Sugar factories located at the both Nile banks where narrow railway and whole stalk wagons receive the cane transported cross Nile by the help of a crane at certain ports. The railway lines started at the back and side gates of the sugar mill and branched along the infield roads through the cane production area. The main narrow railway lines near the mill gates include several grand unions and large number of switches.

Over 2200 km of the narrow gauge railways expanded to maintain feeding sugar industry with the raw materials that represented in sugarcane produced from the adjacent areas on both sides of the Nile as shown on the map Figure (2).

Fig. 2. Light railway expansion areas in the Nile Valley.

Infield roads on which the narrow railway lines constructed may be expanded on a side of an irrigation or drainage channel may cross several bridges and may cross the main railway line of Upper Egypt. Double light railway lines may be expanded on the main roads to maintain easy motion of cane trains travel to or coming from several infield lines connected to the main lines by unions. The sub branches of the narrow railways may be double lines that include a main rail line on which the loaded train move and an auxiliary line for the travel of empty train coming from the mill. This arraignment of auxiliary rail line for the travel of empty train may be limited to certain locations to maintain smooth motion on the light railway lines. Infield railway lines are single lines on which a train moves either empty or loaded.

Figure 3 shows a map of the second oldest narrow railway network (1896) that established to feed Naga-Hammady mill with row cane. The 115 years old cane transport narrow railway network of 420 km long still efficiently working by the help of seasonal maintenance. In this particular region, the contribution of narrow railway transport system may currently exceed 60% of the daily mill capacity.

Fig. 3. A map of light railway network of NH. sugar factory established 1896 (Courtsy, Sugar & Int. Idustry Company)

3. Light railway system transport elements

3.1 Light railway lines

The narrow railway lines established for cane transport initiated with similar gauge of 2 feet (61 cm) that represent the inside width between the rails (Figure 4). The narrow track sleepers are fabricated from cold formed steel plates of 2 m width. The ballast-less narrow track constructed by arranging the steel sleepers 0.75 to 1 m apart directly on the road soil (Figure 5). The two feet spaced rails are fixed to the sleepers with bolts and clamps.

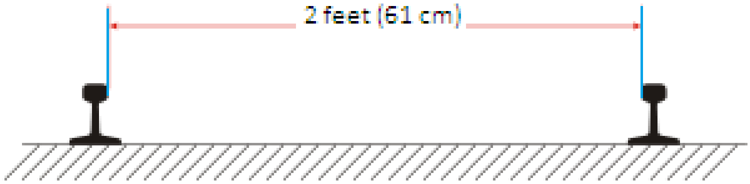

Fig. 4. Size (gauge) of the Egyptian light railway for cane transport

Fig. 5. A balastless narrow railway expanded on a bank of an irrigation channel

Fishplates are used to connect the ends of rails along the track. A short space is left between the ends of the rails for thermal expansion. Since this sort of rail lines are ballast-less expanded on dirt roads with considerably wide interval between sleepers, the alignment of the rail ends at the point of fishplate connection is not always secured. To overcome the probable vertical misalignment at the expansion gap, a short single bolt rail plate is used. Figure 6 show the single bolt alignment short rail piece. Whenever the train is coming from any direction, the near end of the plate is aligned to the end of the rail, carrying the train wheel and turn around the pin to be aligned to the front rail. This simple arrangement largely reduces hard sudden impact, reduces rapid wear and breakdowns of the rail wagons undercarriage.

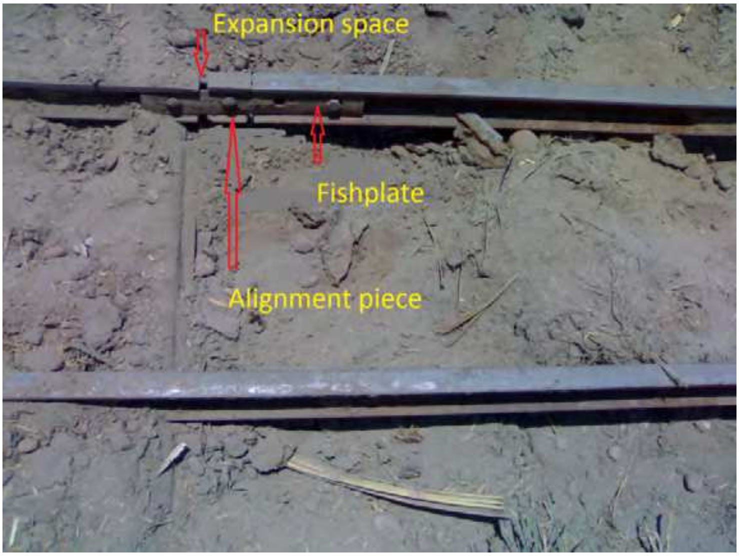

Fig. 6. Rail ends connection

3.2 Light railway locomotives

Variable sizes of locomotive are available to pull the light railway sugarcane train. Locomotives of variable types have been imported mainly from Germany, Romania, Japan, and Slovakia. Based on the statistics, old and new German and Romanian types represent the major numbers of locomotives belong to the sugarcane transport system. The sizes and function of locomotives of the narrow railway cane transport system may be:

- Locomotives of 250 hp and more have been used to work on the main narrow railway lines. Most of these locomotives are of 350 hp operated to pull the empty wagons to the field and pull back the loaded train to the mill. Experienced operators have been employed to drive such locomotives to ensure the train travel safety. The locomotive driver should be memorizing the location of large number of switches and be sure each is switched to the proper direction on his way either to the field or back to the mill. The driver should also be aware about the location of infield roads which the train crosses. A person is assigned to help the driver during the trip. Figure 7 shows one of the narrow gauge railway locomotives of 350 hp that used to pull the sugarcane train.

- Locomotives of power from range from 150 to 250 hp are used to pull the loaded rail wagons inside the mill yard. Such locomotives are used for pulling the wagons for weighing and for unloading. Intensive maneuvering operations may be required inside the mill yard to move the loaded wagons toward the unloading line. The small locomotives also used to clear the discharged wagons from the yard to the departure lines to save more room for the trains coming from the fields.
- Locomotives of power less than 150 hp are used to move the unloaded wagons away from the unloading line. These types of locomotives perform a lot of maneuvering operations inside the mill yard to collect the empty wagons and to move the empty train to the departure line.

Fig. 7. A narrow gauge locomotive on the way to the field

3.3 Light railway whole-stalk cane wagons

Since all the sugar factories followed one company, the light railway wagons fabricated for cane transport size variation is very limited. The wagons designed to be whole stalk loaded parallel to the longitudinal axel of the wagon. Unlike the Australian cane bins described by **Lynn (2008)** show large variation of wagons size that carry chopped cane.

The wagon has two bogies each of four steel wheels on which a rectangular steel flat surface is fixed. Steel columns are bolted vertically to the outer side of the rectangular flat surface that form a basket that hold cane parallel to the longitudinal axle of the wagon. The ground clearance to the bottom surface of the wagon around 60 cm. The wheel diameter may be 32 cm from the flange side and 24 cm from the wheel trade side. The light railway wagon flat load surface may be 6 to 7 m in length and 1.5 to 1.8 m in width and the side columns are 1.4 to 1.6 m in height. Wheel base from the center of the rear wheel of the rear bogie to the centre of front wheel of the front bogie ranged from 5 to 5.7 m.

The loading volume inside the wagon may be ranged from 14 to 18 m^3. The cane is loaded parallel to the longitudinal axle of the wagon. The load may be expanded up to 1 m over the wagon side columns to permit higher capacity of the wagon.

Transverse steel channels welded to the loading surface of the wagon to permit passing the chains under the load while unloading the wagon in the mill. Figures (8) and (9) shows isometric and projection drawings of the light railway cane transport wagon.

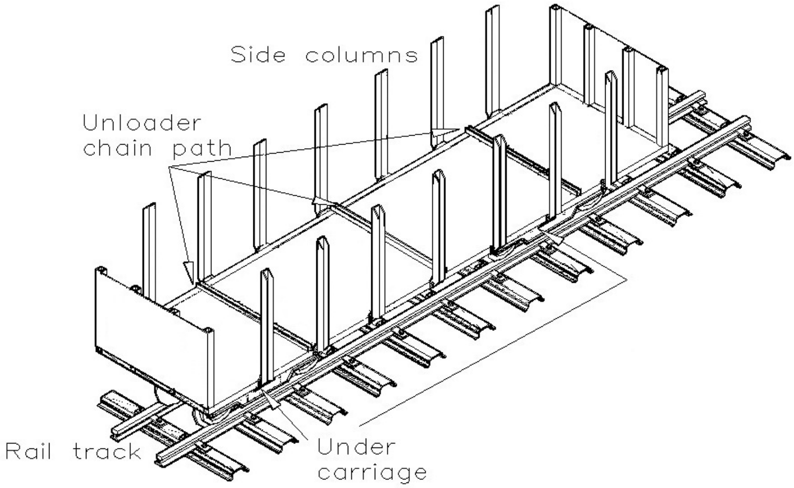

Fig. 8. Isometric of the cane transport light rail-wagon

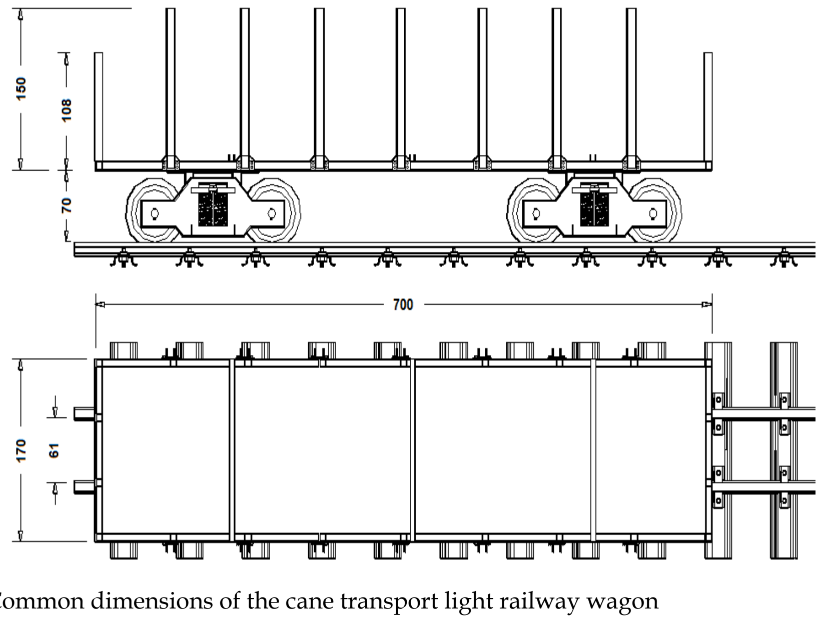

Fig. 9. Common dimensions of the cane transport light railway wagon

3.4 Light railways system operation schedule

The principle objectives of railway wagons operation schedule may include:

1. To secure uniform diurnal arrival of the current of railway wagons to the mill.
2. To reduce the probability of loaded wagons delivery delay.
3. To face the overload transport due to accidental conditions.
4. To secure overnight operation of the mill.

Figures 10 and 11 show the trains while transporting sugarcane. The operation of the light railway system for cane supply to the mill has to be performed according to a pre-defined schedule. The mill seasonal operation period should be approximately estimated based on the daily capacity of the mill, cane production area and average production of the unit area. The average data of the recent juicing seasons would be helpful in that concern.

The size of the railway wagons fleet required for a sugar mill may be determined according to variable conditions. The mill daily capacity represents the total mass of raw materials has to be supplied to the mill around 24 hours. Row cane delivery Schedule plan should determine the quantities of sugarcane to be transported by road vehicles. General estimation of the average rail wagon capacity should be estimated based on the past season data. Cycle time of the rail wagon transport trip should also be clear and specified. In addition to several other factors related to harvesting, infield transport and loading, the rate of the rail wagons breakdowns occurred during the season should be considered.

The rate of row materials delivered by the light railway wagons around the day should be managed by the mill administration to reduce the waiting time at the unloading queue. The mill administration may have to consider the following steps to estimate the numbers of the rail wagons, pull locomotives and operation team around the day:

- The labor operation is arranged into three shifts which are; morning shift that last from 7 am to 3 pm, evening shift from 3 pm to 11 pm and night shift from 11 pm to 7 am.
- Road transport is limited to the diurnal period and vehicles may continue arrive to the unloading queue till the evening. Therefore the supply of road transport may be limited to the morning and evening shifts.
- Supply of sugarcane row materials to the mill during the night shift depend mainly on the light railway system.
- Diurnal operation of the light railway wagons should be considered to secure the shortage of road transport supply to maintain continuous operation of the mill.
- The operation of the light railway wagons is arranged as diurnal and night fleets. The number of railway wagons required for diurnal operation and those required for overnight operation should be estimated. Wagon/s with certain card number/s assigned to transport the cane of certain farmer. A locomotive pulls the empty train to certain region and then pulls the loaded wagons back at specific time.
- Specific time duration is determined for mill yard departure and arrival of each of the diurnal operated trains and the overnight operated trains.

Androw and Ian (2005) reported that several mill regions within the Australian sugar industry are currently exploring long-term scenarios to reduce costs in the harvesting and rail transport of sugarcane. These efficiencies can be achieved through extending the time window of harvesting, reducing the number of harvesters, and investing in new or upgraded infrastructures. As part of a series of integrated models to conduct the analysis, we developed a capacity planning model for transport to estimate the (1) number of locomotives and shifts required; (2) the number of bins required; and (3) the delays to harvesting operations resulting from harvesters waiting for bin deliveries. The schedule developed to operate the Egyptian system may have similar objectives **(Abdel-Mawla 2011)**. For example, the second oldest sugar mill (N. H.) started operation in 1896, the light railway system used to transport almost 100% of the cane delivered to the mill. At present, the light railway wagons deliver only 50% of the mill daily capacity. The mill holds the most long light railway network (410 km) expanded through the cane fields. The mill also has 1700 light railway wagons ready for operation. Large amount of field data concerning crop, field, environment and labors required for the proper design of the light railway operation schedule. Concerning the determination of the rail wagon numbers, the basic data presented in Table 1 may be necessary.

Item	Value
Mill capacity	= 1.7 million ton/season
Estimated season duration	= 140 days
Daily supply	= 12000 tons/day, approximately
Required hourly supply	= 500 tons/h
Average rail wagon load	= 9 tons

Table 1. Basic data required to estimate the number of light rail wagons.

Table 2 presents estimation of the narrow railway wagons fleet size required to secure adequate supply of the mill daily capacity of cane row materials.

<table>
<tr><th colspan="2" rowspan="2">Shift</th><th rowspan="2">Shift duration</th><th rowspan="2">Required cane supply ton</th><th colspan="2">Light railway contribution</th><th rowspan="2">Required wagons</th><th colspan="2">Departure time</th><th colspan="2">Return time</th><th>Mill yard waiting</th></tr>
<tr><th>%</th><th>ton</th><th>From</th><th>To</th><th>Fro m</th><th>To</th><th>h</th></tr>
<tr><td rowspan="2">Diurnal</td><td>Morning</td><td>7 am
15 pm</td><td>4000</td><td>50</td><td>2000</td><td>223</td><td rowspan="2">7 am</td><td rowspan="2">16 pm</td><td rowspan="2">12 am</td><td rowspan="2">19 pm</td><td rowspan="2">6-10</td></tr>
<tr><td>Evening</td><td>15 pm
23 pm</td><td>4000</td><td>10</td><td>400</td><td>45</td></tr>
<tr><td colspan="2">Night</td><td>23 pm
7 am</td><td>4000</td><td>90</td><td>3600</td><td>400</td><td>19 pm</td><td>00 am</td><td>23 pm</td><td>6 am</td><td>10</td></tr>
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Table 2. Estimation of the railway wagon fleet size

The efficiency of the narrow railway cane transport system may be largely improved by reducing transport cycle time as follow:

- Reducing the time of the loaded wagon waiting in the mill yard.
- Mechanize cane loading operation.
- Improve the rail line management related to switches and signalling system.

Fig. 10. A narrow rail train is loaded with cane and ready for pull

Fig. 11. Train loaded with on the way back to the mill

4. Light railway wagons loading and unloading

4.1 Loading

The cane transport administration of the mill distributes the empty light railway wagons according to the schedule. The driver of the locomotive leaves the wagons in the trans-loading site scheduled for cane delivery. Farmers bring the cane from inside fields to the location at which the wagons loaded. The common activity is to start loading the wagons in the morning. Loading may be done manually or mechanically according to the availability of mechanical loaders.

4.2 Manual loading

The light railway of loading surface 60 to 70 cm high from the ground surface may be loaded manually (Figure 12). Two labors start carrying cane bundles, climb a ladder and place them inside the wagon. Even though the manual loading is considered adverse operation, it may permit some important advantages to obtain a higher density load such as:

- The labor loaders may fit the cane bundles tightly to ensure efficient use the whole volume of the wagon.
- The labor loading may permit employing a knifeman who is working over the wagon to cut the curved parts of the cane Figure 12. After the labor place the cane bundle in the loading area, the knife man cut the uneven parts of the cane stalks to facilitate higher density load. This activity may be important specially if the cane is taken from a lodged field.
- The labor loading may also permit a better chance to expand the load by force fit vertical columns of cane stalks when the load level become over the steel side columns of the wagon.

Fig. 12. Labor loading of rail-wagons with sugarcane

4.3 Mechanical loading

Few mechanical cane loaders were available till the Aswan Mechanization Company established at 1980. At that time large number of Bell type cane loaders imported and operated. Even though, the company stops purchasing new loaders and the majority of their loaders become old, the farmers bought those old loaders, rebuild them and bring them to operation again **(Abdel-Mawla 2010)**. Recently, other tractor mounted loaders may be locally developed and operated for cane loading. Figure (13) shows mechanical loading of the light rail-wagons using a tractor mounted loader developed by the author 2011.

Light railway system also designed to handle the cross Nile transported cane. The system depends on the similarity in design and size of the cane holding bins fixed on the ship to that of the light railway wagons. Actually, light rail wagon frames fixed on the ship each of them have certain code number. Farmers load their cane each in certain frames on the ship. After the ship load complete, it travels across Nile to the unloading crane. A light railway line passes opposite to the crane. The crane lift the load conserving its dimension and structure and place it into a wagon (taking the same code number) waiting on the rail line. As soon as the rail wagon receives the load it pulled away waiting for pull to the mill. Another light rail wagon pulled to the crane loading area as indicated in Figure (14).

The mechanism of unloading the light rail-wagons to the mill conveyor may vary from mill to another. A crane that carry the loaded wagon up then inverse the wagon to discharge the load over the conveyor may be found in Kom-Ombo mill. The empty wagon then returned back to the rail line and pulled away to give the chance to another wagon to be unloaded. The other common unloading mechanism may include a crane that left the wagons load with help of chains and place it over the conveyor. The unloaded wagon then moved and another one advanced toward the crane. Figure 15 show the chain un-loader which commonly used in sugar mills.

Fig. 13. Mechanical loading of light railway wagons using a tractor mounted loader (developed by the author).

Fig. 14. Light railway system handle cane transported cross Nile

Fig. 15. Unloading light rail wagons.

5. Light railway problems

5.1 Problems related to rail track wear out

According to **Abdel-Mawla (2000)**, the narrow railway network faces breakdown problems due to the wear of long parts of the rail track. Currently, the light railway transport around 40% of the total cane delivered to sugar mills as general average for the eight sugar mills.

As previously explained some of the light railway systems started about 140 years ago. The old narrow railway expanded on the infield roads have been facing problems of steel components worn out. In spite of continuous seaseonal maintenance, the railway network have several corroded parts. Some of the narrow railway tracks constructed on the clay soil of the infield roads which is in the same level of the neighbor fields. The sleepers, bolts, fishplats and other parts of the rail track gradually covered by the road dirt. Moisture of underground water as well as moisture infeltrated from irrigation water may reach the rail track. The clay soil preservs moisture around the buried track causing intensive rust of th steel parts.

In the routin maintenance, the labors uncover the rail and change the wear-out parts that are easily to descover. Figure 16 show the rusted steel sleepers of the narrow railroad track.

Some parts of the old light railway network may become out of service because of the intensive breakdowns due to wear out. In most cases the track should be completely replaced otherwice several accedents expected due to loaded wagons turn a side or track climb where intensive losses may be occurred . Whenever such accedents repeated, the farmers abstain from transporting by the light railway and go for road transport even though it is more costly.

Fig. 16. Balastless narrow rail track showing intensive ruste of sleepers buried in the clay soil

5.2 Problems related to system operation

The light railway system employed for cane transport may be considered a slow system where the loaded vehicle wait for long time to be pulled back to the mill. The empty rail wagons distributed to several fields by a distribution locomotive. After these wagons been loaded with cane, the distribution locomotive move them to certain location where the stuff responsible for the train operation attach the loaded rail wagons together. The train loaded with can attached to the pull locomotive and start move back to the mill. Therefore it may last for long time before the train reach the mill. Actually, the train has to travel at limited speed (10-15 km/h) to avoid the accedents may occure at the intersections of the railroad and infield roads. Also train has to stop at the railroad switches where the locomotive driver or his helper has to swich it himself. The railroad swiches may be abused by young farmers, so that the locomotive driver himself should be sure about its position before cross.

The longer duration from the time of loading to the time of weighing the wagon load in the mill is critical for the farmer. The moisture losses from the vegitative load may be of high rate specially in such hot dry weather. Science the mony value of the load will be determined according to its weight, farmers may prefer to go for faster transport system to avoid vehicle load weight losses.

5.3 Problems related to farmers behaviour and road conditions

Some other railroad tracks may be constructed on the irrigation channel banks. In such cases, water pipes passes under the railroad track to convey irrigation water from the channel to the field. Intensive soil erosion may occurred under the rail track because of the repeated activities while opening and closing the irrigation pipes as shown in Figure17. Some other farmers may park their animals on the railroad whenever they are out of the season which may be a reason of soil erosion under the railroad and/or the loosen of the track and sleepers. In several cases, the narrow railroad trak expanded on the same infield road on which farmers, animals and equipment move. Therefore, some parts of the track may be covered with dirt Figure 18. Also, some equipment drivers do not maintain the safety of the narrow railroad track while moving.

Fig. 17. Soil Erosion under the railroad.

The narrow railroad has to be doublicated at several locations. The main track is for the loaded train travel from the field to the mill. The auxilary track established at certain locations for the travel of the empty train coming from the factory to the field. The additional track also maintain the manuver of the locomotives while collecting the loaded wagons together and the manuver of the pull locomotive to turn in front of the loaded train before pulling it back to the mill. It has been observed that intensive herbs may grow on the auxiliary patrs of the railroad Figure 19. Intinsive herbs may cause wagon wheels climb off the track.

Fig. 18. The narrow railroad constructed on the middle of an infield road with parts covered with dirt

Fig. 19. Herbs intensively grow and harm the auxiliary railroad

6. Light railways transport system maintenance

6.1 Equipment maintenance

Routine maintenance of Locomotives has been continuously done during the operation season. After the operation season end (in June), seasonal inspection of the locomotives started at the mill workshop. Important repair should be accomplished to make the total locomotive power ready before the next operation season start at the end of December. Some locomotives purchased during 1960's still working by the help of continuous maintenance and repair. The rail wagons maintenance also take place at the end of the season. Replacing old were up or broken bearings, gracing, replacing the twisted columns, and welding broken parts may be the major activities done to rail wagons. Replacing wear out wheels, broken springs and repair damaged bogies are also common activities of the rail wagons maintenance. Some old wagons may become out of service, the staff may decide to consider them salvage and forward a report to replace them. The new rail wagons for cane transport fabricated in the heavy equipment assembly factory belongs to the sugar company in Cairo to replace the salvage wagons.

6.2 Rail track maintenance

Maintenance of the rail track start after the operation season end in June and should be finished at December before the new season start. Technicians walk over the rail track inspecting the type and location of the breakdowns (Figure 20). After localizing breakdowns, technicians uncover the wear out parts of the track to perform maintenance and repair activities. The operation of railway network maintenance may include clear dirt or weeds that cover the track, tightening loose bolts and nuts and replace wear parts. Replace wear up sleepers may be the most common activity during the maintenance season Figure 21. The rails parallelism and rail gage should be also inspected and adjusted. The final step of the narrow railroad maintenance is to test and adjust the rail level Figure 22. A monthly report has to be forward to the narrow railway engineering administration showing the completed job.

Fig. 20. Two technicians inspect the probable breakdowns of the rail track

Fig. 21. Replacing the corroded steel sleepers of the rail track

Fig. 22. Balancing the level of the rail track

7. Light railways future

As previously discussed, each narrow railway network constructed and started operation simultaneously with the sugar factory initiation. The light railway networks belong to the old sugar factories initiated during the 19th century and those initiated at the early period of the 20th century used to supply 100% of the mill daily capacity. The narrow railway network expansion has been very limited compared to the expansion of sugar cane production area. According to **Soltan and Mohammed (2008)**, the area of sugarcane has been increased from less than 200,000 acres at 1980's to about 350,000 acres at 2008. Therefore the light railway of sugarcane transport stay constant and the cane area expanded more than 40 % outside the network. Since the role of the narrow railway sugarcane transport system declined from about 90% to about 40%. Considering the 40% decline because of cane area expansion outside the network, therefore declined of the light railway system transport may only be about 10%. Actually the percent contribution of the cane transported may be decreased but the total tonnage transported by the narrow railway system may be increased because the average unit area production increased and the mills now working at their full capacities.

The change of some farms to road vehicle may be because of the availability of their own vehicles or the advantages offered by road transport. The most important advantage offered by road transport is the short duration of transport cycle that save the excessive moisture losses that reduces the total weight and money value of the wagon load. In contrast, applications have been forward from several farmer groups to expand the light railway sugarcane transport network to their plantations. The light railway network of sugarcane transport may grow parallel to the cane production area whenever narrow rail tracks expanded according to the applications forward to the sugar company from farmers.

The sugar company has been developing experiences of light railway track maintenance, wagon fabrication and locomotive repair to maintain long life and efficient operation of the system. Constant efforts have been exerted by the company to replace locomotives and rail wagons which become out of service. The sugar mills may have hundreds of locomotives most of them compatible to the 2 feet rail gauge and more than 10,000 railway wagon for whole stalk loading. The company has been improving the level of locomotive maintenance and the design of the railway wagons to facilitate better role of the system.

The light railway sugarcane transport system was always able to transport cane with lower cost as indicated in Figure 23. Finally it may be concluded that the role of the light railway sugarcane transport system did not actually declined but remain constant while the mill capacity and the cane production increased. Since the alternative transport represented in road transport operated diurnal and it is difficult to use the road vehicles as storage bin, a minimum contribution of the narrow railway transport have to be conserved. The minimum role of the light railway system transport may be equivalent to the percent of daily capacity of the mill required for night shift. Reference to Figure 1 it could be observed that the role of railway transport system is not expected to show more decline. The sugar company organized special administration for narrow railway engineering that construct the rail track, fabricate wagons and been responsible for the system maintenance.

Australia may be considered as one of the countries achieved the most important development in the field of light railway transport of sugarcane. In his comment to the future of the sugarcane light railway of Australia, **John Browning (2007)** stated that "Cane railways will continue to surprise and to interest, and they will remain "special" to the men who operate them, to the many visitors to the areas in which they run, and to those who simply love railways". It has been recommended that, some of the modern techniques developed in countries such as Australia to control the light railway sugarcane transport cycle time should be considered.

Finally, the light railway for sugarcane transport represents the backbone of the raw material feeding system for sugar industry in Egypt. The system has several advantages compared to road transport such as lower transport cost, higher reliability, higher stability and minimum accidents occurred. Application of the advanced techniques for minimizing transport cycle duration expected to help for regaining the pioneer role of the light railway transport system. Practical ideas to increase wagons capacity and to improve mill yard management have been currently developed to speed up the system. Light railway transport system will continue being the familiar lovely transport system for sugarcane farmers.

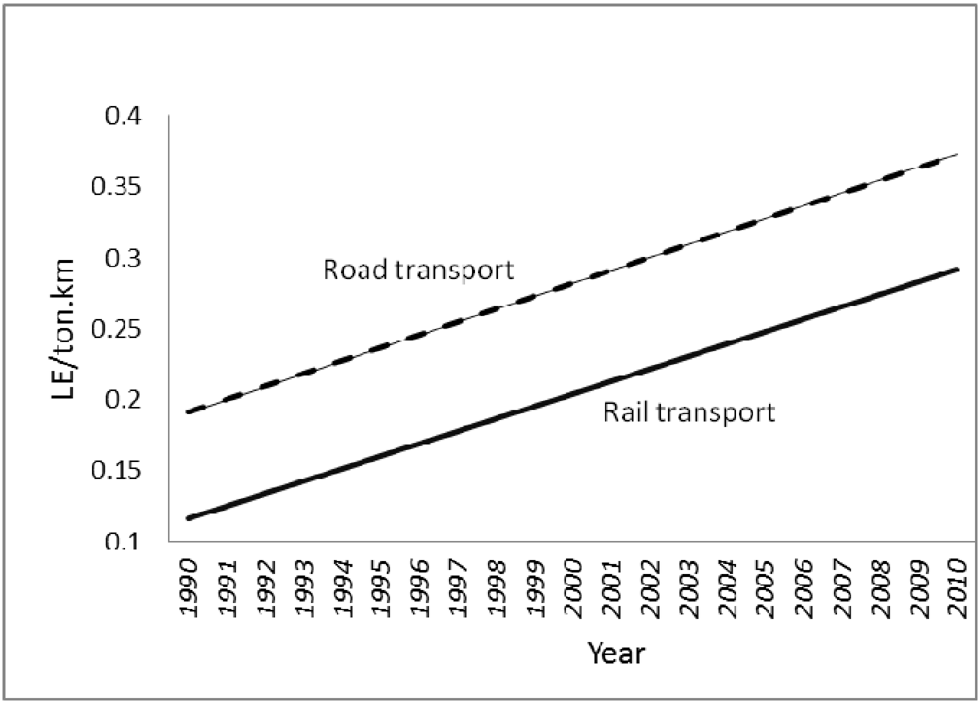

Fig. 23. Cost of light railway transport compared to road transport

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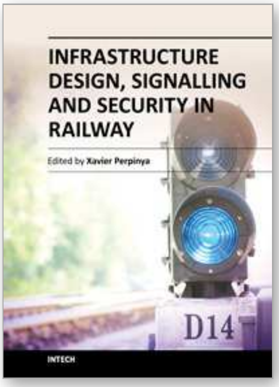

Infrastructure Design, Signalling and Security in Railway

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Railway transportation has become one of the main technological advances of our society. Since the first railway used to carry coal from a mine in Shropshire (England, 1600), a lot of efforts have been made to improve this transportation concept. One of its milestones was the invention and development of the steam locomotive, but commercial rail travels became practical two hundred years later. From these first attempts, railway infrastructures, signalling and security have evolved and become more complex than those performed in its earlier stages. This book will provide readers a comprehensive technical guide, covering these topics and presenting a brief overview of selected railway systems in the world. The objective of the book is to serve as a valuable reference for students, educators, scientists, faculty members, researchers, and engineers.