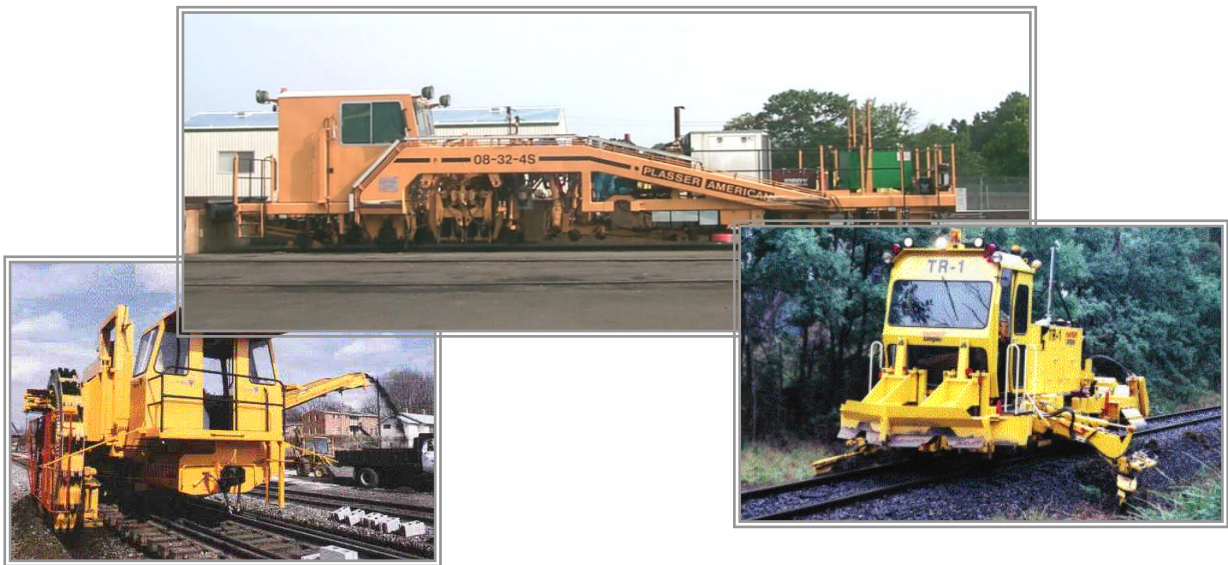




Track Maintenance Training



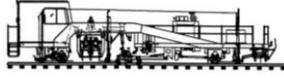
BALLASTED TRACK

MODULE TWO

BALLAST

Metropolitan Atlanta Rapid Transit Authority

Infrastructure Training



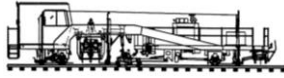
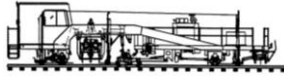
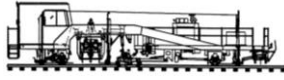


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Ballast Track

Introduction

Ballast track instruction will provide a review of MARTA standards and practices. At the end of this course, students will be able to properly identify the function of ballast, sub-ballast, sub-grade and grade along with other ballast related components in accordance with MARTA Maintenance Procedures.

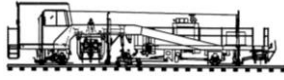
Requirements

Test scores must be 80% or higher on all written evaluations. Only one retest will be allowed on any written evaluation without additional training. All MARTA Track and Structures personnel must demonstrate knowledge of MARTA ballast procedures and the ability to identify ballast related items.

Each student will be asked to complete a class/instructor evaluation at the end of the class.

Learning objective

At the end of this lesson the student will be able to identify all ballast related components found in track construction and describe their function .



Section Objectives

Describe MARTA ballast standards.

Describe the process of transmitting the load of a train from the tie to the remainder of the track components.

Describe how ballast restrains track.

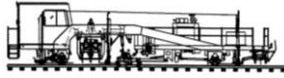
Describe the main functions of ballast..

Describe what problems are found in fouled ballast..

Describe the different ways to clean ballast.

Describe surface and alignment as it pertains to ballast.

Describe ballast handling equipment and its function in ballast restoration.



BALLAST

A. ECONOMY OF BALLASTED TRACK

Ballast is used as the **foundation** for the great majority of all track, even though there are other types of construction that we used.

Rails may be fastened directly to concrete slabs or stringers. Ties may be imbedded in concrete. Certain types of bridges do not require ballast for the tracks which are built on them. Although such alternatives are available, in most situations ballasted track is the most practical and economical type of construction.

1. Ballast Requires Maintenance

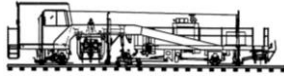
Ballast, even in the best constructed tracks, will not perform all of its functions without attention. There are times when maintenance will be required. This lesson will investigate ballast problems and procedures for correcting them.

2. Ballast From the MARTA Track Safety Standards

Will be inspected daily. Observe for the following:

Clean, well compacted ballast (# 4) must be located in the cribs to the top of the crosstie or to within an inch of the bottom of the rail, whichever comes first.

A **12” shoulder** must be maintained on the high side of the curve. At least a **6” shoulder** must be maintained at other locations. (Low side of a curve & both shoulders on tangent track)

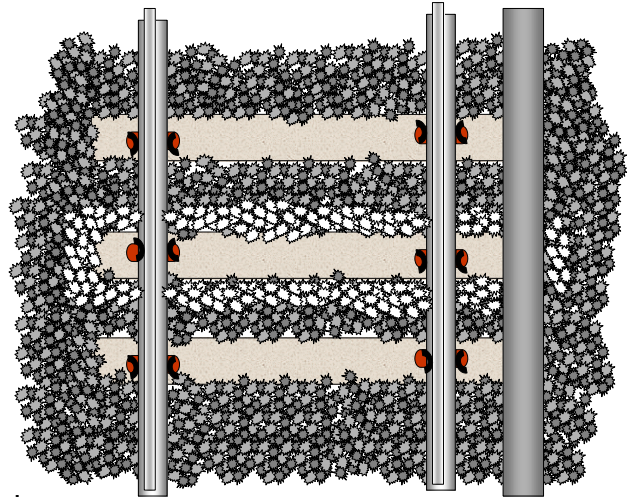


Ballast must not be touching the bottom of the rail. **One inch (1") minimum** must be maintained between the base of the rail and the top of the ballast.

When a track has been disturbed for maintenance, it must be examined carefully for stability. The ends of the ties should be carefully observed for any indications of lateral track movement.

In **extremely hot weather (100 degrees F or greater)**, advise management personnel ASAP of any locations at which there is less than a standard ballast section.

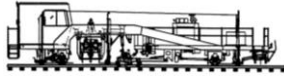
Note and record the locations of extremely **“white”** ballast around the edges and ends of ties. This is an indication of **“pumping”** or poorly tamped track and should be scheduled for maintenance.



Ballast missing or gaps occurring at the end of the ties could be an indication of lateral track movement. This may occur prior to track buckling in hot weather or prior to the developing flat spots in a curve in cold weather. Report to T&S Supervisory personnel ASAP.

Certain track maintenance procedures result in disturbance of the ballast which can reduce its capacity to restrain the track from unwanted lateral movement.

The passage of train traffic over the track or the use of ballast stabilizers can restore this capacity by consolidating the ballast.



3. Ballast - General Standards

The general standard for ballast states the duties which ballast must perform. Although the description is brief, it covers the requirements of ballast quite well. A crosstie base, side and ballast shoulder resistance contribute to the overall lateral resistance of the track. In general, each contributes (base 50%, side 20-30% & shoulder 20-30%) to this resistance but the ratios can vary dependent upon ballast conditions. Lateral resistance also varies in location depending on the ballast shoulder geometry (slope), crosstie size and weight and type and the state of ballast consolidation (compaction).

Unless it is otherwise structurally supported, all track must be supported by material which will:

- (1) Transmit and distribute the load of the track and railroad rolling equipment to the sub-grade;
- (2) Restrain the track laterally, longitudinally, and vertically under dynamic loads imposed by trains and thermal stress exerted by the rails.
- (3) Provide adequate drainage for the track.
- (4) Maintain proper track crosslevel, surface, and alignment.

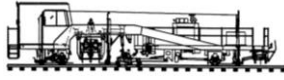
B. TRANSMITTING LOADS

First, consider the requirement that ballast transmit the loads which are placed on it to the sub-grade.

There is no question that the ballast will transmit (or send on) the loads to the material under the ballast, if the ballast is supporting the ties.

Suppose, that in a small area, covering a few ties, the ballast is not supporting the track.

- Perhaps, these ties are hanging loose when there is no train on the track.

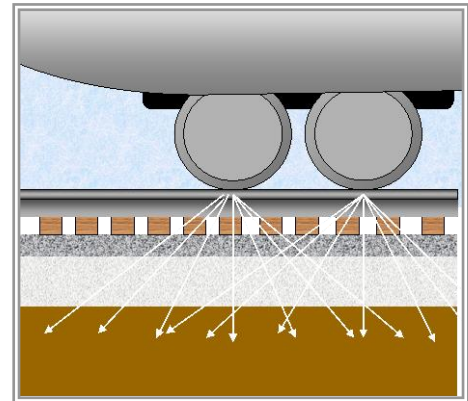


If a heavy wheel load is placed over this point, the track will be depressed.

- Also known as pumping.

The bottom of the ties establish contact with the ballast. However, because of the stiffness of the rail, most of the load is being transmitted through nearby ties that were firmly supported by ballast.

In this case, the ballast under the loose ties is not carrying its share of the loads.



- In the language of the MARTA standard, it is not properly transmitting the load.

The corrective action is to place ballast under the loose ties, that is to tamp them, so that the loads will be transmitted to the sub-grade as intended.

1. Distributing Loads

In the lesson on The Track Structure, it has been previously shown that depth of ballast is the key to distribution of loads.

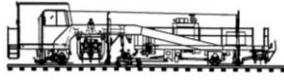
- Within practical limits, the deeper the ballast, the more the loads which are imposed at the bottom of the tie will be spread out where the ballast meets the sub-grade.

The standards do not indicate how much depth of ballast is required to distribute the loads.

- This can vary substantially.

One thing which will affect the amount of ballast required is the nature of the traffic.

- A track which carries only a small amount of traffic may be adequately ballasted with 6-inches of ballast below the bottom of ties.

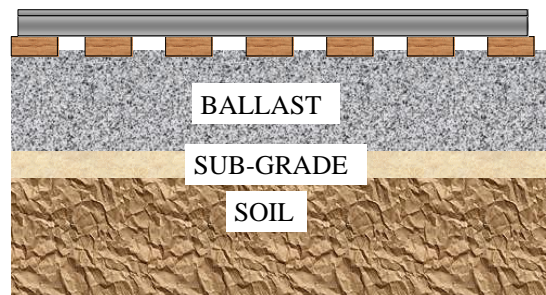


- Tracks with a high density of traffic, predominately heavy wheel loads or **higher speeds**, may need considerably more depth of ballast to adequately distribute the loads.

The sub-grade material may also be a factor in the depth of ballast required. Some soils cannot support as heavy a load as other types of soil.

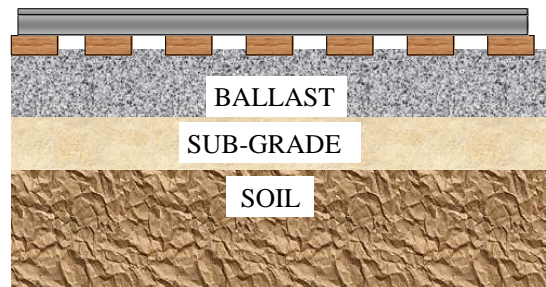
The weaker soils will require the loads to be spread out over larger areas, if they are to adequately support them.

Some soils will require better distribution of the load in areas of heavy rainfall, than they will in normally dry regions.



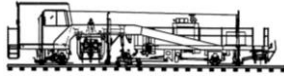
In most situations, if a problem of inadequate ballast depth exists, it can be corrected without much difficulty. Additional ballast is unloaded. The track is given a general raise, and ballast is tamped under the ties.

- If necessary, in order to attain the desired depth of ballast, the process is repeated.
- Exceptions to this are where limited overhead clearances prevent such a raise, or where other conditions require that a fixed rail profile be maintained.



C. RESTRAINT OF TRACK

The second requirement of the MARTA ballast standard is that the ballast will restrain the track laterally, longitudinally, and vertically under dynamic loads imposed by railroad rolling equipment (trains) and thermal stress, exerted by the rails (expansion or contraction due to weather conditions).



- In most ways, the ability to restrain the track laterally and longitudinally are inter-related.
- Most lateral displacement results from failure to restrain the track longitudinally. It has been shown that rail tends to creep longitudinally.
- The main reasons are the influence of rail traffic and temperature changes within the rails.

1. Rail Movement

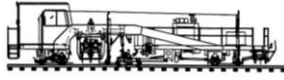
If rail is permitted to move longitudinally, at some point in the track and at some period of time, higher than normal compressive stresses will develop in the rails. If these compressive stresses become large enough, the track will begin to move laterally, or vertically, or buckle.

- This can be extremely dangerous.
- It can happen quite suddenly, in front of or even under a moving train.
- A serious derailment may result.

Such hazards can be avoided if the rails are restrained from moving longitudinally. This restraint must be provided by other parts of the track structure.

Anchors are applied to the rail. Rail anchors, if properly applied, will keep the rails in the same position relative to the anchored ties. If the ties, to which anchors are applied, are not adequately restrained, the rail will still be free to move longitudinally. It is necessary that these ties be restrained from creeping.





Pandrol clip act as their own rail anchors, thus preventing lateral, vertical and longitudinal movement of the track.

The ties must be restrained by the ballast.

- The amount of restraint provided by the ballast can be very small or it can be considerable.



There are several things which determine how much restraint should be provided.

2. Amount of Ballast

The amount of ballast in the cribs between ties is one of the more important factors in the restraint of ties.

- You should know what your standards are for the amount of ballast in the track structure.

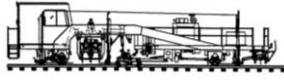
Many transits and railroads require that ballast cribs be full to the top of the ties, at least for welded rail.

- Such standards should never be ignored, even for short periods.
- If the standard is not met, temporary operation of trains may be justified, but at reduced speed.

Consideration must be given to existing and probable rail temperatures. Any such expediency should only be for short periods, until adequate ballast is provided.

Slow-speed train operation may minimize immediate danger.

It must be recognized that insufficient ballast may permit some a longitudinal movement. A later application of ballast will not correct this.



- This could combine with some subsequent condition, such as a high rail temperature, to cause excessive compression.

3. Bond between the tie and the ballast

The lesson on the Track Structure directed attention to the importance of the bond between the bottoms of the ties and the ballast, in providing longitudinal and lateral support.

It must be recognized that this bond is at a minimum under certain conditions.

These include:

- Track which has recently been raised or lined.
- Track in which tie renewals have recently been made.
- The installation of new track.

This bond will be restored gradually, under traffic. Until this happens, this lessened capability for restraint from this source must be recognized. This makes other sources of restraint, such as full tie cribs, of particular importance at this time.

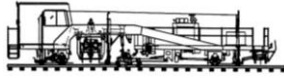
4. Ballast compaction

It is possible to increase the amount of initial compaction by the use of equipment designed for the purpose.

MARTA uses a Ballast Compactor or Consolidator for areas where ballast will be



disturbed. This machine vibrates and places a downward pressure to the track. In doing so the compactor causes the ballast to interlock with each other and form a good bond with the bottom and the sides of the tie. It would take days of train traffic to accomplish the same results.



Track disturbed by track maintenance work loses much of its lateral resistance. Operating trains at reduced speeds minimizes dynamic wheel forces while resistance is being regained.

- This alternative method involving a **dynamic stabilizer**, restores resistance faster than train traffic alone. Temporary speed restrictions on stabilized track can normally be restored sooner or no speed restrictions will be needed at all.

The total longitudinal restraint which the track structure can develop also depends on the number of ties which are anchored. If other restraining conditions are favorable, anchoring of additional ties is another alternative which may be considered. (Ties anchored in the yards only.)

All of these factors are important to longitudinal restraint, and in this manner contribute to lateral stability.

- Some of them are also effective directly in the contribution of lateral support.

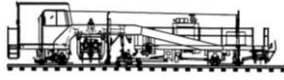
5. Type of ballast

The amount of restraint which can be expected from the ballast also depends on the type of ballast.

- Ballast with sharp, angular edges, such as crushed rock, or crushed slag are superior in this respect.
- Types in which the particles do not interlock as well, such as gravel or cinder, have less potential for restraint.

Gravel or cinder can be quite adequate for light to moderate traffic, yet may be inadequate for heavy-traffic conditions.

Ballast which has been undisturbed for an extended period, except for the settling effects of rail traffic, will be relatively compacted.

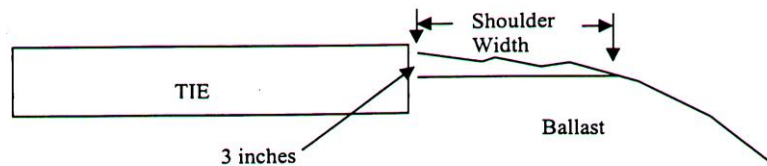


Ballast which has recently been placed in track or disturbed, will be relatively loose and have less restraining capability.

6. Shoulder ballast

Another condition which is insignificant from the longitudinal standpoint, but of importance to lateral restraint, is the **shoulder ballast**. The amount and location of shoulder ballast, the type and compaction all determine effectiveness.

- This, is another area in which you should become familiar with MARTA's standards or policy.



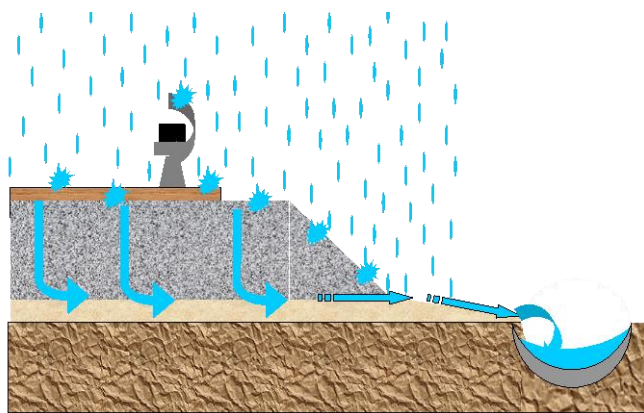
The MARTA standard also stated that ballast must restrain the track vertically. This capability has been discussed to some extent in terms of transmitting and distributing loads. It will be investigated further in parts of this lesson which follow.

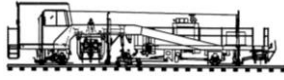
D. DRAINAGE

Track must be supported by material which will provide adequate drainage for the track. In these few words, the standard covers one of the most basic and essential elements of track maintenance.

A track which is well drained can withstand the effects of many other undesirable conditions for a considerable time without mishap.

A poorly drained track will be expensive to maintain, and a constant threat to unrestricted train operations.





A poorly drained track is one in which moisture is prevented from escaping rapidly from the ballast, sub-ballast, and sub-grade.

- This may be caused by conditions within the ballast which retain water.
- It may also be caused by roadway conditions beyond the ballast which prevent the flow of water away from the track structure.

1. Fines

Conditions within the ballast consist of fine particles of material which fill the voids between the pieces of ballast.

- Many fine materials, when mixed with water, form mud.
- Mud within the ballast acts as a lubricant.
- Ballast loses its ability to restrain the track.
- This is particularly true of vertical restraint.
- The ballast has reduced capability of uniformly transmitting and distributing loads.
- Its ability to maintain cross level and surface is impaired.

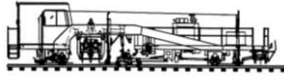
The fine materials which cause ballast to become fouled and prevent proper drainage can come from any of several sources.

- One such source is leaky cars. Grease and oil can prevent water from draining properly. Vegetation growing in the ballast.

On railroads, coal, ores and other bulk materials spilled onto the track surface, work into the ballast and fill the voids which are intended for the drainage of water.

2. Slopes and Drainage Ditches

Check slopes for possibility of slides and falling rock. Observe and note any slope erosion. Ditches, catch basins, culverts must be clear of obstructions. It is the responsibility of the Track Walker to clear obstructions if possible.



All drains and catch-basins must be checked on each trip through the inspection area. Any obstructions should be noted and cleared.

Note that catch basins frequently clog after heavy rains. Please note and report any “**standing water.**”

One of the most essential elements of track maintenance is a comprehensive drainage system. Drainage facilities (bridges, or culverts) should be given careful detailed consideration during inspections.

- Openings under the track are used to channel and divert water from one side of the roadbed to the other.

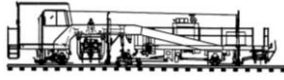
Each drainage structure shall be maintained and the Track Walkers should note conditions that would affect the integrity of the structure, such as culvert pull apart or separations, sink-hole, crushing or uneven settlement due to failure of or lack of head walls, too steep a gradient, sink-hole and insufficient support. Drainage openings must also be inspected and notice given where debris has accumulated to such an extent that expected water flow cannot be accommodated.

Culverts designed with submerged inlets are common. Where questions are raised concerning the adequacy of drainage structures, the T&S Management should be consulted.

Track Walkers and Maintenance employees must take note of the conditions of:

- Right-of-way ditches, Culverts and bridge inlets;
- Water carrying structures or passageways;
- Outlets or tail ditches;
- Scouring of embankments, piling or piers in channels or at abutments; and filling in of passageways from silting, sand wash or debris.

Track Walkers and Maintenance employees must notify the T&S Management of any drainage condition deemed hazardous, or potentially hazardous, to the safety of train operations or to track personnel.



3. Sub-ballast

Undesired materials may enter the track structure from such varied sources as mud slides, erosion of adjacent fields and run-off of drainage from hi-rail accesses.

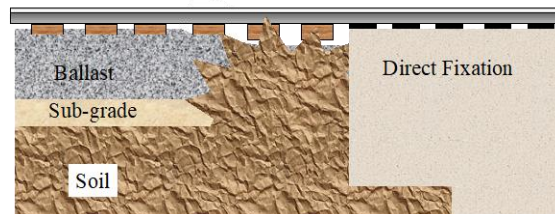
Many tracks, having been constructed many years ago, and have no well defined sub-ballast.

The flexure of the track structure under moving trains can promote a tendency to suck mud upward from the sub-grade into the ballast.

This flexure frequently is greatest in the vicinity of rail joints and transitions.

This leads to the conditions commonly described as pumping joints or pumping track, in which the ties in the vicinity of joints or abutment will be surrounded by mud. Such mud has frequently been drawn upward from the roadbed.

Another source of fine materials in the ballast is the breakdown of the ballast.



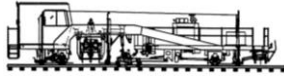
- This will usually be negligible in the better ballast materials.

Ballast materials of lesser quality may tend to wear down their surfaces as a result of the abrasive action between adjoining pieces of ballast under moving trains.

- Some materials are also susceptible to deterioration from the effects of weathering.

A condition which causes ponding of water, such as a blocked ditch or culvert can create a problem within the ballast.

- If such water backs up into the ballast, it can carry mud or silt. It can accelerate pumping conditions from the sub-grade.



Even small amounts of impurities in the ballast can permit weeds to develop.

- If vegetation is permitted to grow, the root systems of the plants will reach downward and draw more undesired materials into the ballast.



Sometimes, it is possible to correct a condition which leads to fouled ballast promptly. A ditch or culvert obstruction may be cleared before the ballast is adversely affected.

A new growth of weeds in the ballast can be chemically treated before any substantial root system becomes established.

There will be locations in many tracks where the ballast becomes fouled with undesirable materials that impair the drainage.

- Usually, it will become difficult to maintain good track surface at such locations.

Some action is needed that will correct, or at least sufficiently improve the ballast condition, so that it will function as intended. There are several procedures that are used to deal with such ballast problems.

E. SMALL FOULED BALLAST PROBLEMS

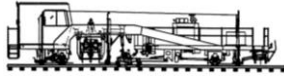
The first situation that will be considered is the small, isolated spot in which there is a ballast drainage problem. Perhaps, it consists of one or two pumping joints.

- It may have been caused by a joint defect.



This needs to be corrected when dealing with the ballast problem.

- It may be an excessively wide rail-end gap.



The problem could be a battered rail-end which needs welding. Perhaps, the joint bars are worn or loose. Possibly, defective joint ties may be involved.

Whatever the reason, vertical movement of the track under each wheel load has created a pumping action with mud traveling upward into the ballast from the underlying roadbed.

As long as the problem is not extensive enough to justify heavy equipment, it is appropriate to manually dig out the ballast which has become fouled with dirt or mud.

- Perhaps, pneumatic tools may be available to increase the efficiency of the operation.

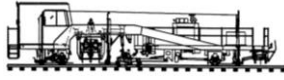
It may be the intention to dispose of the fouled ballast, replacing it with other clean ballast. If the material has dried sufficiently, the ballast might be cleaned and returned to track.

- This is done by sifting the dirty ballast, usually on ballast forks.
- This should be done clear of the track and ditches, so that the dirt cannot again become a problem.

The extent of the ballast excavation will depend on the size of the area affected. It is usually desired to promote drainage laterally from the track area, through the ballast shoulder to the ditch or slope.

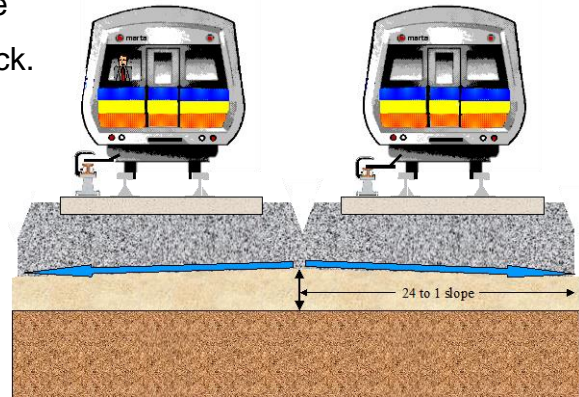
In the case of multiple track, it may be necessary to decide whether part of the drainage should be directed toward the inter-track area (6 foot).

This will depend on the condition of the ballast in the center ditch, the presence of inter-track drains, the track grade and the presence of structures that may retard drainage. This judgment should be based on what will happen to water if it is directed towards the center ditch.



Here at MARTA, it is preferable to have the water to drain off to the field side of the track. The way the MARTA road bed is designed the high point or apex of the track is in the center area between the two tracks.

- Check the Track Component Drawing Book for an example.



At some depth, the excavation and cleaning of the ballast will stop.

- To a large extent, future rainfall will descend in an approximately vertical direction to this level.

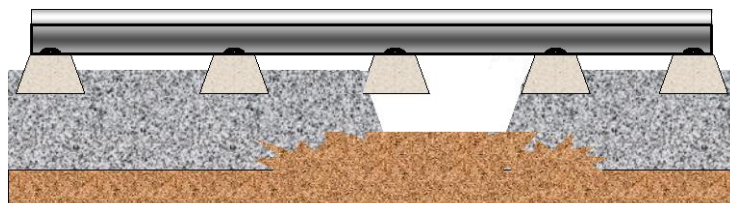
It will then begin to spread out, seeking low spots in the surface of the underlying, hard-packed, fouled material. It is therefore very important that this separation of the clean and underlying, un-cleaned material be as uniform as possible.

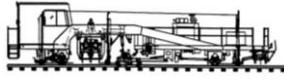
It should be gradually sloped so that water will flow laterally, out of the ballasted area. If there are uneven pockets of clean ballast, water will tend to collect in them.

If the ties within the fouled ballast area can be removed, and the ballast under the ties is cleaned, this will produce the most desirable condition.

Sometimes, this is not practicable. Then the practice is to clean the ballast in each tie crib to a depth of **several inches below the bottom of the ties**. This creates a series of trenches filled with clean ballast between the ties.

- The bottoms of these trenches should be cleaned to a greater depth throughout the affected area.





This, too, **should have a uniform** separation between cleaned and un-cleaned ballast, sloping away from the track.

- This arrangement will promote some leeching of the dirt or mud from under the ties into the cleaned areas between the ties and on the ballast shoulders.

In any case, moisture will drain out of the foul ballast under the ties much faster. The result will be more stable ballast under the ties.

F. LARGER FOULED BALLAST PROBLEMS

Many problems involving poorly drained ballast, are too extensive to be corrected by procedures such as those just described. One such situation might consist of a track through a cut, where inadequate drainage has caused the ballast to become fouled with foreign materials from the ditches.

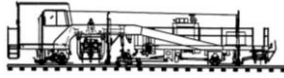
In another case, there may be a series of muddy spots in the ballast resulting from an undesirable rail condition; an unstable sub-grade material, together can be the cause of another trouble spot.

Perhaps, you know of a location where trains carrying mostly bulk commodities stop frequently. You may find that this location has dirty ballast due to car leakage.

- Many variations of such conditions are possible. It is not unusual to have stretches of track where the ballast tends to become fouled.
- Drainage and track stability problems frequently develop at these locations.

There are various ways in which the problem within the ballast can be corrected.

- It should be emphasized that such efforts will not bring permanent results unless the source of the problem is also corrected.



This may mean restoring or improving drainage facilities. Rehabilitation or replacement of rail, might be in order. An unstable roadbed condition could require special treatment. The source of the problem must be identified so that a decision can be made as to what action will be undertaken.

1. Track Raising

One of the ways in which the problem of fouled ballast might be handled, is to raise the track through the affected area.

- In most cases, a track raise intended to deal with this type of condition should be several inches in height.
- This approach does not get rid of the mud or dirt; instead, it is buried.

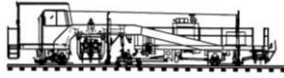


Sufficient new ballast is unloaded in the track before raising, to maintain the proper ballast section after the job is finished. The raise needs to be adequate to permit some of the new, clean ballast to be placed under the ties when tamped.

- A **skin lift** will probably result in fouled ballast from the cribs being tamped under the ties.
- This procedure involves making a general raise of the track. In the process, irregularities in surface are removed. **The general raise is usually one inch or less.**
- This amount will be greater in the areas in which low spots exist.

General raises of the track structure, regardless of the amount of raise, are frequently called **out-of-face raises**.

This procedure eliminates the mud seal which frequently form around the ends and sides of the ties.



- When ties are surrounded with mud seals, water is trapped between the tie and the mud seal in wet periods. Problems of track stability worsen quickly under such conditions.

After the track is jacked to its new grade, each tie is separated from the hard packed bed of ballast on which it formerly rested.

- Where fouled ballast conditions exist, these tie beds will almost certainly have compacted dirt mixed with the ballast.

These tie beds form a surface through which water is not readily absorbed. If the process of tamping new ballast under the tie does not disturb this old tie bed too badly, the old bed may serve as a means of diverting water away from the track. Under such conditions, it might be said that each of the old tie beds act as sort of a mini sub-ballast surface.

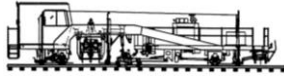
Attempting to correct fouled ballast conditions by raising the track would not be the best approach, if permanence of the job is the most important consideration.

It should be recognized that the conditions which exist in the ballast following such a procedure are less than ideal.

- It is quite possible that the track may revert to its former undesirable condition after a period of time.
- Whether that period of time is short or long may determine whether this approach to the problem is justified.

Use of a track raise as a means of dealing with a ballast problem has certain advantages.

- Compared to other alternatives, this method is relatively quick, convenient and economical.



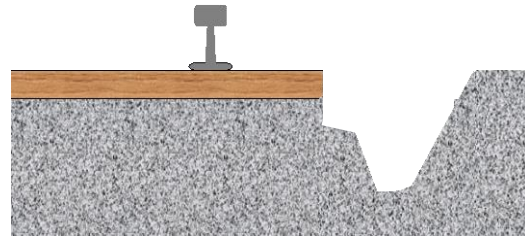
Tamping equipment is usually fairly accessible, at least in comparison to the specialized equipment needed for alternate approaches. The cost of working track by this method is substantially less than by most other methods.

G. SHOULDER BALLAST CLEANING

Another way in which such a problem can be approached is to clean that part of the ballast which lies beyond the ends of the ties. This process can be quite beneficial in a great many cases. It can be particularly effective when used together with a track raise.

Equipment is used that removes the fouled ballast from the shoulder areas.

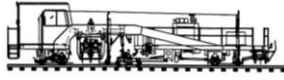
- In multiple-track territory, it can also be removed from center ditches.



A conveyor system carries the ballast to a vibratory screen which separates the dirt from the ballast. The cleaned ballast is then returned to the track. The dirt which has been removed from the ballast is picked up by a separate conveyor system.

- In most cases, it is cast to the side of the roadway.
- Some equipment provides for coupling to a standard hopper or air dump car.
- This permits loading the dirt when working through cuts or other locations not suitable for disposing of the spoil by casting.





Because of the size and investment in the equipment required, most ballast cleaning is done by contractors that specialize in such work. The large investment is justified by the high rate of productivity of these units. Normally, several miles of track are cleaned per day.

This type of ballast cleaning promotes the lateral flow of water from under the track, through the cleaned shoulder ballast.

- Some leeching of mud from the cribs and under the ties, to the cleaned shoulder areas frequently takes place.

One important feature of the ballast cleaning procedure is the insertion of a steel tooth under the tie ends. This is done after the shoulder ballast is removed and before the cleaned ballast is returned.

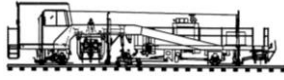
- The steel tooth causes the ballast within a few inches of the tie ends to fall to the bottom of the excavation.
- This eliminates any mud seals that may be present at the tie ends, and improved drainage of water from under the ties.

A track raise, which results in clean ballast being placed under the ties, together with this type of ballast cleaning, can result in a condition in which most rainfall will be quickly diverted away from the ballasted areas which support the heavy vertical loads.

- The remaining fouled ballast is more likely to be fairly dry and capable of supporting these loads.

One limitation on the capability of all of the ballast cleaners, is imposed by wet conditions. All ballast cleaners are most effective when the ballast is dry.

- Dry dirt will readily separate from the ballast during the screening process.



When there is a muddy condition, there is a tendency for some of the mud to cling to the pieces of ballast during the cleaning process. Except for the surface material, muddy ballast tends to dry slowly.

In wetter climates, ideal conditions may occur infrequently. When ballast is wet, an initial pass with a ballast cleaner may result in an inadequate cleaning job.

However, an initial pass will effectively loosen the ballast and expose it to the air. If reasonably dry weather occurs during the next few days, a second pass with the ballast cleaner will usually produce excellent results.

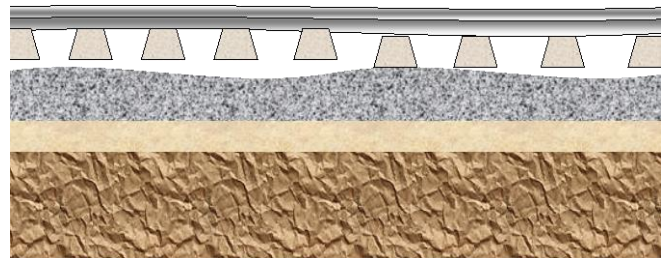
H. UNDERCUTTING

Occasionally, severe ballast problems will be found where experience shows the previously described treatments to be inadequate.

Cleaning of ballast under and between the ties might be required.

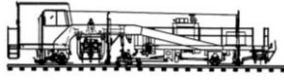
- There may also be conditions present, such as clearance restrictions, which prevent raising the track. In such situations, undercutting of the track may be a solution to the problem.

Undercutting consists of removing all of the ballast from under a track to a pre-determined depth, without removing the track.

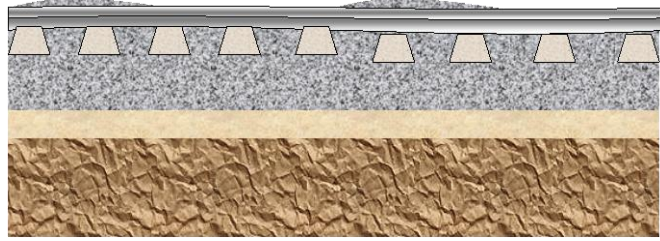


- Some undercutting processes waste the ballast which is removed.
- Under some roadway conditions, as in narrow cuts, this material must be loaded and removed.

Behind the undercutter, the track settles onto the underlying bed of un-cleaned material. In this condition the track may have adequate surface to permit operation of a work train.



This facilitates the unloading of new ballast. The track is then raised to grade and tamped.



Undercutters can do an excellent job of either removing or cleaning ballast throughout the

entire ballast cross section area, without removal of the track structure.

Productive capability, in terms of track footage per working hour, is substantially less than can be obtained with a shoulder ballast cleaning operation or with an efficiently organized track raising operation.

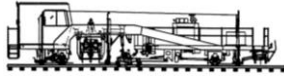
There are other limitations on the capability of track undercutters. In most cases, the insertion and removal of the undercutting assembly from the track is time consuming.

- This is usually necessary at grade crossings, turnouts, and many bridges.



Several manufacturers offer specialized undercutters intended to perform the undercutting function at turnouts, grade crossings and other specialized locations where the larger, production type undercutters cannot work effectively.

It should also be recognized that during the undercutting procedure, ties will be left hanging from the rails. They will fall off if the tie condition will not hold the spike heads to the rail base. Tie renewals should either be made ahead of undercutting, or provision made for doing it while the track is skeletonized.



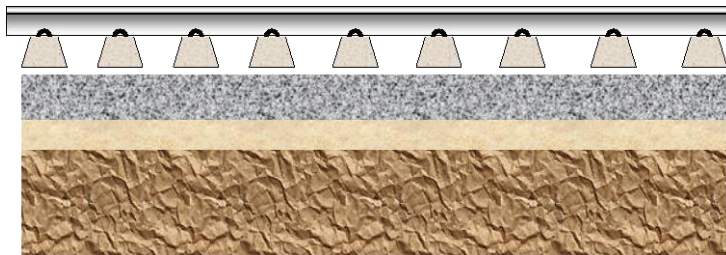
Because of these limitations, track undercutting is mostly restricted to locations where special problems exist. The total mileage of track which is rehabilitated by means of undercutting is relatively small because of costs and limitations on productivity.

I. BALLAST SLEDDING AND PLOWING

These procedures involve placing a device known as a ballast sled, or one which is called a track plow, under the track.

- The sled or plow is either part of a self-contained unit or pulled by other means. (Locomotive)

As it moves ahead, the ties and track structure fastened to the ties are raised over the sled or plow. The ballast falls below the device and is leveled to a smooth surface. If the sled is used, the ballast is leveled approximately as it falls, resulting in a raise of the track.

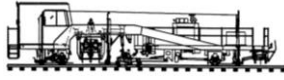


The single track plow has "V" shaped blades, spreading the fouled ballast towards both shoulders.

The double-track plow, spreads the fouled ballast toward one shoulder.

1. Ballast Sled

Raises track on old crib material or sleds new ballast. Hydraulic controls maintain raise and hold original cross level.



2. Single Track Plow

Removes all fouled ballast to both shoulders. Keels hold plow on line and level to keep original elevation and level of track.

3. Double Track Plow

Removes all fouled ballast, deposits it outside either shoulder, leaves smooth, level surface on undisturbed sub-ballast.

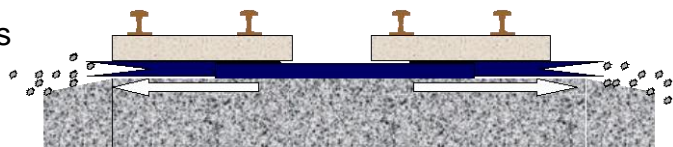
The intent is, that the old, fouled ballast will remain to perform the functions of sub-ballast. The plow or sled will leave a smooth enough surface to promote run-off of water along this surface.

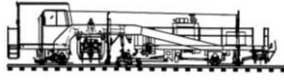
A work train can unload new ballast with the track surface which exists while skeletonized.

- Depending on the amount of new ballast desired under the ties, the track can either be raised and tamped after placing ballast, or another pass can be made with the sled.

The sledding operation permits a substantial depth of new ballast to be placed under the ties quickly. If this is done, more ballast can be unloaded, and final surface can be obtained with tamping equipment.

- Plowing and sledding operations are particularly suited to situations where it is desired to upgrade the quality of the ballast.
- The old ballast is utilized as sub-ballast.
- If greater width of roadbed is needed to support the new ballast, this can be attained by use of the plow, instead of the sled.
- A much more uniform separation is attained between the old, fouled material and the new ballast.





- This can improve lateral drainage.

In cases where the old ballast consists of too much fine material to clean effectively, this approach can also be considered.

Such equipment is not suitable for locations where overhead clearance is limited. Where obstacles such as turnouts, crossings, and bridges occur frequently, the effectiveness of this equipment is reduced.

All the mechanized ways of cleaning ballast that were discussed here may not be suitable for use here at MARTA.

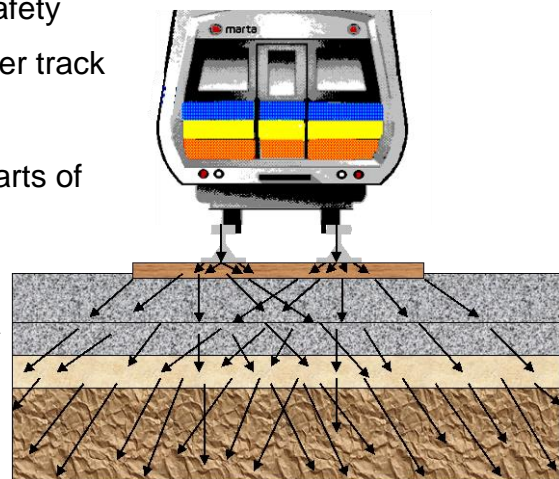
- With so much equipment running under the track, chances are that a great deal of damage would occur. But it is important to realize just how important clean ballast is to the track.

J. CROSS-LEVEL, SURFACE AND ALIGNMENT

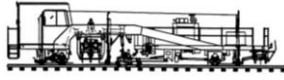
The fourth requirement of the MARTA Track Safety Standard for ballast, is that it will maintain proper track cross-level, surface and alignment.

- In effect, this summarizes the other parts of the standard.

Proper cross-level, surface and alignment are the goals which are desired to achieve through maintenance of the ballast.



If the ballast properly transmits and distributes the loads placed on it; if it restrains the track laterally, longitudinally, and vertically; and if it provides adequate drainage, then the ballast will do its part in maintaining proper track geometry.



1. Tamping

One of the functions of a tie is to spread out the loads which the tie receives from the tie plates.

Ballast has less ability to support a concentrated load than the tie. More area is needed for the ballast to support the tie than for the tie to support the tie plate.

It would, therefore, appear to be desirable to uniformly tamp the entire bottom area of each tie, thus uniformly distributing the load.

Unfortunately, if this is done, problems sometimes develop over a period of time. It should be realized that while a tie is relatively stiff.

- Under heavy loads some bending can take place.

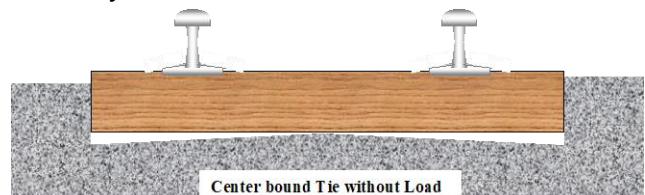
This is particularly true of older ties. The result is that the ballast under those parts of the tie directly under the rail, gets a somewhat larger part of the load. This ballast will therefore tend to compact and become depressed first.

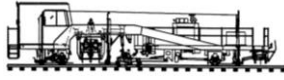
The part of the tie which is furthest from the rail is at the center of the track.

- If a tie is uniformly tamped throughout its length, the ballast at the center of the track will be the last to become depressed by repeated wheel loading.

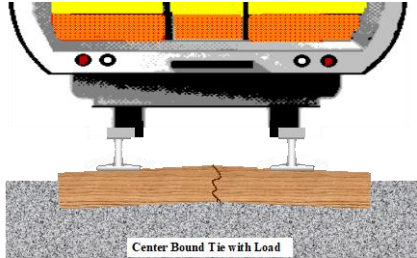
When such a condition develops, the track can, in affect, pivot about the center of the ties. Such a condition is commonly known as **centerbound track**.

- The surface of centerbound track when subjected to the load of a train may be entirely different from its appearance when no train is on it.



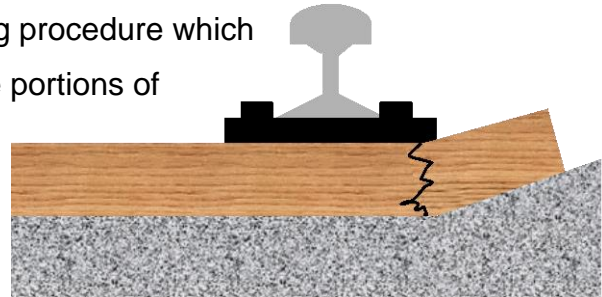


To avoid centerbound track, ties are not tamped in the portions close to the center. It is desirable to fill in any voids which may exist under this part of the tie, but not to compact such ballast.



Most tamping procedures do not compact the ballast under the tie between points about 1-1/2-feet inside the rails.

Another situation to be avoided is a tamping procedure which results in compacting ballast only under the portions of the tie outside of the rails. This can cause ties to break in the area under the tie plate or tie pad. When this has occurred, it can be readily detected, since the end of the tie will slope upwards.

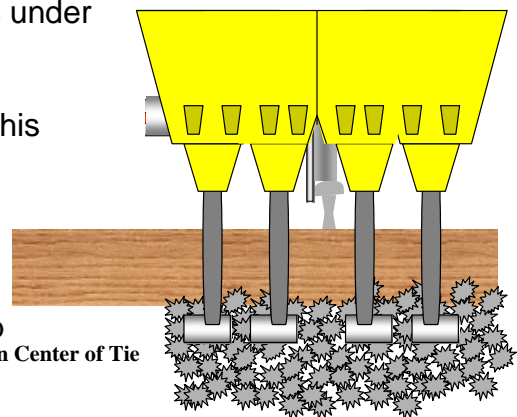


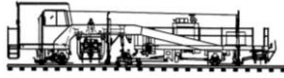
When manual tamping procedures are used, it is customary to give particular attention to the compaction of ballast under those portions of the tie directly under the rails.

- This is good practice, as compaction at these locations should be at least as great as under other portions of the tie.
- Most mechanical tampers accomplish this indirectly, rather than directly.

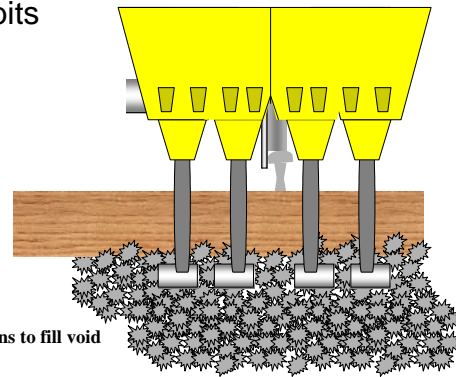
This indirect compaction is done because of the difficulty of designing equipment which will tamp directly under the rails.

- Modern tampers are capable of attaining a considerable amount of compaction.





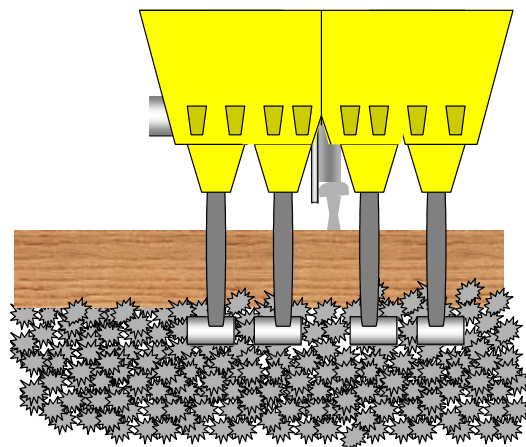
Once the ballast directly in line with the tamping bits is compacted, further tamping causes lateral movement of the ballast under the ties. By this means good compaction can be attained directly under the rails.



In order to attain a well tamped tie, the tamping cycle should be of sufficient length to produce such results.

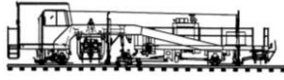
- The amount of tamping required will vary due to such factors as the type of tamper, the amount of raise and the type, size, and condition of the ballast.

The number of insertions and the duration of the insertions of the tamping bars needed to properly tamp a tie will change as these conditions change.



The best approach to this problem, is to carefully observe the performance of the tamper you are working with under a variety of conditions.

After tamping, dig out a few ballast cribs to a depth of a few inches below the ties. Observe the amount of ballast compaction under the ties. Try a different tamping cycle on some other ties; then dig out around them to compare the quality of the tamping. Do this until you find the shortest tamping cycle needed to provide good ballast compaction.



When working at a location where the amount of raise varies a good deal from the first situation, or where the ballast conditions are quite a bit different, repeat the entire process again.

It is entirely possible that you might receive instructions regarding the tamping procedure. These could be quite proper for average conditions, but you could encounter some unusual conditions. Such instructions do not relieve you of knowing whether an adequate tamping job is being performed, of taking the safe course and of informing your superiors of the existence of such conditions.

K. DISTRIBUTING BALLAST

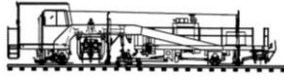
Several of the procedures that have been described in this lesson require the placement of additional ballast in the track. The usual means of delivering the ballast is in either special ballast car or specially designed dump trucks.



The cars are placed in a train, and suitable openings are made at the bottom of the cars. Ballast flows onto the track as the cars are moved at a speed which will deposit the desired amount of ballast on the track structure.



While the operation appears to be simple enough, it takes planning, good judgment, and knowledge of the equipment available in order to do a good job of unloading ballast.



Before starting to unload ballast, you should know how much of a track raise is anticipated. This should be used to determine the quantity of ballast to be unloaded.

It would not be practical to give actual figures in this lesson for you to work with.

- There is too much variation in the weight of ballast materials, as well in the size of cars used.

A good approach is to work out a rule-of-thumb for the number of truckloads needed per area, per inch of raise.

For example,

Suppose that a certain type of ballast in a certain size truck should be unloaded at the rate of

- Truckloads per 100 yards for a one inch raise.



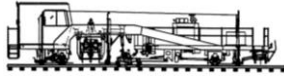
This material should then be unloaded from such trucks at the rate of

- 10 per 100 yards for a 2-inch raise
- 15 per 100 yards for a 3inch raise.

This information can then be converted to the number of rail lengths required for one truckload of ballast.

It is also necessary to have some idea in advance as to the adequacy of the present ballast section.

- It could be that there is somewhat too much ballast for the present level of the track.
- If so, the amount of additional ballast required will be somewhat less.
- The reverse may also be true.



If special ballast cars are used, they may contain doors specifically designed to control the flow of ballast in the desired pattern.

- Such equipment can not only increase the efficiency of the ballast unloading operation, but can be beneficial to the track work which follows.
- Accurate unloading of ballast will reduce the amount of re-handling which is required later.



Where it is necessary to use conventional hopper cars, some provisions to control the flow of ballast is necessary. A fully opened hopper door will result in a large quantity of ballast falling out, with possible derailment of the car when it is moved.

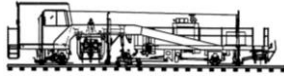
- The method used to control the ballast flow will depend on the construction of the hopper cars and the ballast pattern which is to be placed in track.

When sufficient ballast is unloaded to permit a raise of about 3-inches or more, a tie is usually placed on top of the rails, just ahead of the rear truck of the car being unloaded.

- The tie will slide on the rails ahead of the wheels, and clean ballast off the rail heads, preventing a derailment.

Sometimes, pans are attached to the cars, under the hopper doors. These can restrict the rate of flow of the ballast.

- If holes are cut in the pans, additional ballast can be placed in track in the vicinity of the holes. This is usually in areas where the tamping bars will be located, adjacent to the rails.



On some cars, it is possible to chain the hopper doors, thereby restricting the opening. Experience will be needed to determine the proper opening of the hopper doors, to get the desired rate of ballast flow.

Sometimes, the same thing is accomplished by attaching a block and tackle assembly to the hopper door and to a convenient hook up point near the car end.

Should either of these methods be used, an approximately even flow of ballast can be expected for the full width of the hopper doors.

L. BALLAST HANDLING EQUIPMENT

After ballast is unloaded, it might require some further handling to permit proper tamping.

- This depends on the capabilities of the equipment used to unload it.

After the track is raised, the ballast section will need shaping. Points where there is an excess or insufficient amount of ballast will have to be adjusted.

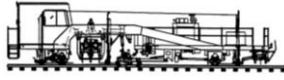
Other maintenance operations, such as tie renewals, may disturb the ballast, and require that it be dressed up when the work is completed.

1. Regulator

Such functions can be performed effectively by equipment specially designed for the purpose.

- One such machine is the Kershaw ballast regulator.

The Kershaw ballast regulator can help on some or all of the following problem areas.



1. Regulating Uneven Shoulders

- Before regulating, shoulders are uneven and tie ends exposed.

2. Ballast wing has yard capacity and automatically reverses for operation in either direction. Horizontal adjustment cylinders are completely enclosed and protected.

- After regulating, shoulders are full and uniform.



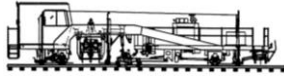
Before track has been rehabilitated, excess ballast is plowed out and the track is resurfaced.

3. Dressing the Center Ditch

- Shoulders are regulated.
- Broom is used to sweep remainder of ballast from track center.
- With job completed, shoulders are uniformly full with tie ends covered.

Center ditch can be dressed, as above, flat, concave or to other configurations with special wing blades.

- Plowing Away From Tie Ends
 - Plow-away blades on rear of wings easily remove material away from ends of ties.
 - Dressed center ditch on a curve. Note uniformity of ballast shoulder.
 - Before scarifying, vegetation grows on shoulder, up to and under tie ends.
4. Production of tie crew can be increased by plowing away from ties to be renewed.



Broom reel and baffle assembly swings up slightly for sweeping switches. Reel is equipped with used train line air hose.

Snow can be effectively removed from switches with the optional Kershaw snow switch cleaner attachment.

2. Transferring Ballast

Blades are set for transfer. On first pass, material on the tie ends, is plowed to center of track. At the same time, the reversible wing is pulling additional material from the side ditch to tie ends for next pass.

The above is the result of one pass with the plow, which has transferred ballast from the ends of the ties to center of track.

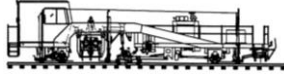


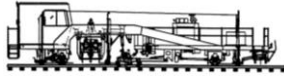
On the second pass, the blades are transferring at near capacity and moving material completely across the track. Additional passes can be made to transfer more ballast if desired.

Plowing in and Plowing out

After sweeping the track center and dressing shoulders, the job is complete as shown above. The ballast that was once in the ditch is now on the outer shoulders.

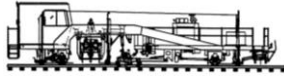
In a matter of seconds, the plow blades on the Kershaw Ballast Regulator can be easily rotated for plowing out, or for plowing in, on photo at right.



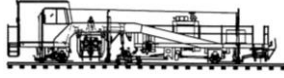


EXERCISE QUESTIONS

1. What is the advantage of having a substantial depth of ballast under the ties?
2. Name two reasons for longitudinal stresses in a track structure.
3. Under which condition is track most likely to be unstable?
 - a) A track which has recently had rail relaid
 - b) A track which has recently had an out-of-face raise
4. Under what condition is ballast likely to provide more longitudinal and lateral restraint?
 - a) Ballast in track which has had no recent maintenance work
 - b) Track which has recently had some of the ties removed
5. What part of a tie should not be tamped?
6. What is the purpose of shoulder ballast cleaning?
7. Spot surfacing is an effective way of eliminating pumping joint conditions. True or False?
8. Tamping only the portion of the ties outside of the rails should be avoided because it is likely to cause center bound track. True or False?



9. When using a shoulder ballast cleaner, what is an important procedure that is used to help eliminate mud seals under the tie ends?
10. When is the best time to renew the ties, before or after the under cutting is completed?
11. One of the uses of a track plow is to raise the track on top of newly unloaded ballast.
12. Partly empty ballast cribs can be the cause of a line kink at the heel of a nearby frog.
13. When mechanically tamping a track, two insertions of the tamping bars should always be made.
14. Rails tend to creep longitudinally because of rail traffic and temperature changes.
15. The only way to control rail creeping is to apply additional rail anchors.
16. If there is too much ballast on one shoulder and not enough on the other shoulder, a ballast regulator can efficiently transfer some of the ballast.
17. It is necessary to clean ballast to the bottom of the ballast section in order to get good drainage of the track.
18. Ballast should be unloaded in windrows at the ends of ties, so that the tamper operator can see the ties clearly.



19. A certain track is laid with 39-foot rail. You are instructed to unload 8 cars of ballast per mile. Approximately how many rail lengths should one car load cover?