CONTROL AND ANALYSIS OF THE STATE OF TIMBER SLEEPERS

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Summary: *Railway sleepers are infallible element in railway track system. Their function is multiple. Hardwood timber is the most frequently used material for railway sleepers. After projected life period, most of railway sleepers become less capable of meeting performance demands. It is very important task in maintenance process to control increasing of axle loading on railway, and to prove sleeper's ability for further utilization. Maintenance costs of timber sleepers increased in recent years. Railway sleeper inspections for a long time were done by hand. This process requires skilled and trained staff. Automatic condition monitoring considers a variety of methods and procedures for examination of uniformity, quality and serviceability of construction, without causing damage to it. Automatic vision systems collects images in precisely determine area. After taking images, pattern recognition approach serve to classify the condition of the sleeper into classes, good or bad. Determination of causes for sleeper failures is crucial to minimise track maintenance costs. Besides mechanic cracks in timber, there are also several reasons for sleeper damage. Environmental societies favor use of non toxic materials in production of timber sleepers. It is recommended to use biological wood protection methods, in accordance with environmental regulations. Totally destroyed sleepers has to be replaced with proper kind, according to loadings and maintenance possibilities. New age sleepers from composite materials could replace concrete and steel sleepers, but need to be more investigated in performans on real truck.*

Keywords: *timber sleeper, loading calculation, monitoring, sleeper maintenance, composite sleeper, biological wood protection*

1. INTRODUCTION

Railway sleeper has multiple functions in railway track, so its condition needs to be in required state. The most common type of sleeper appearing on railway tracks all over the world is made of hard wood timber. After projected life period, most of railway sleepers become less capable of meeting performance demands[1,2]. Maintenance costs of timber sleepers increased in recent years. State off the sleeper could be good for further use, need to be adapted or not good for use [3]. For sleepers state determination there are

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visual methods, manual and authomatic. Manual way is oldest type of recognition and gives good results but depends of stuff. Authomatic considers monitoring sleeper with special vehiche. This way could determined several features as presence and number of the cracks, average crack length, average crack width and horizontal length of the plate[2]. The most serious failures of sleeper are fungal decay and end splitting.
Some sleeper degradation states is not possible to improve and need to replace it[4]. [5,6,7]. If condition of sleeper is still good enough for exploatation, but was mention some early degradation, engineer sugests methods to stop growth of damage [8]. Also, there are situations where some damages, like fulgal decay an end splitting, could be prevented in production process [9,10].
Sometimes, sleepers are treated in regenerative process. This is a way to keep old sleepers in usage with some regenerative methods. For further use, after regeneration of wooden sleeper, is necessary to control currrent dimensions. It is necessary to control resistant moment for appropriate axle load from vehicle. This consideres all regenerative processes, where sleepers' cross section changes dimensions. [11]

2. TASKS, ADVANTAGES AND DISADVANTAGES OF TIMBER SLEEPERS

Railway sleepers are the most important element in railway track system. Their function is multiple:
- spread wheel load to ballast,
- hold rails to gauge,
- transmit lateral and longitudinal forces,
- insulate rails electrically,
- provide a base for rail seats and fastenings.

Hardwood timber is the most frequently used material for railway sleepers. There are more than 2,5 billion timber sleepers in function all over the word. It has a long history of exellent performance on railway, because of it's adaptability. Timber sleeper are easy to handle, to replace very fast. This is important, especially on lines with frequent traffic [1,2]. After projected life period, most of railway sleepers become less capable of meeting performance demands. Timber sleepers are subjected to mechanical and biological degradation leading to failures. Because of bioligical disadvantages, timber sleepers need to be treated with creosote. Impregnating timber with creosote according to environmental society is hazadous. Replaced hardwood sleepers should be treated as ecologycly dangerous waste [1].
Maintenance costs of timber sleepers increased in recent years. Every kind of sleeper has projected life. Replacing degradated timber sleepers with new one is one way maintenance. This is not just tipical element replacement. It sometimes considers reusing fastening system and rails. Problem appears, because, it is very dificult to find good quality wood for sleeper, and if there is, need to be treated with creosote or other dangerous materials. Because of it's characteristics and dimensions, it is not always possible to replace timber with concrete or steel sleeper. These kinds of sleepers require special equipment for installation and more time than need for timber sleeper. There are many researches working on new age sleepers, but shoud not be rejected idea for some

regeneration before any necesary replacement. Best way is to study and determine mechanism of sleeper degradation and determine right maintenance criteria [3].

3. CONDITION MONITORING

Railway sleeper inspections for a long time were done by hand. This process requires skilled and trained staff. According to opinion of skilled personnel, sleepers in good condition imply: do not bear long cracks from the outer edge into the fastening, do not bear wide cracks on the surface, produces a sharp sound when struck with a hammer or an axe, have a metal plate which is not sunken into the sleeper and fastening system is still firmly attached to sleeper. On the other side, bad condition implies: long cracks from the outer edge into the fastening system, wide cracks on the surface, dull thud sound when struck with an axe or hammer, metal plate sunken into the sleeper and fastening system rattle when sleeper is struck with axe. This kind of investigation sometimes implies conflicting factors, so investigator has to be someone with a lot experience to consider combination of visual and acoustic examination and determine sleeper condition [2].
In lack of unskilled stuff, could be made serious error. New age condition monitoring considers a variety of methods and procedures for examination of uniformity, quality and serviceability of construction, without causing damage to it. Automatic vision systems collects images in precisely determine area. In case of sleeper monitoring that would be part from the rail to the outer edge of the sleeper, since, cracks, metal plate and fastening system are within this area. Camera is placed on vehicle capable to move on track. Images are taken on both sides of the sleeper. After taking images, pattern recognition approach serve to classify the condition of the sleeper into classes, good or bad [2]. Monitoring sleeper this way could be declared several features as presence and number of the cracks, average crack length, average crack width and horizontal length of the plate. Mention process establish sleeper damage is caused by high level loading. Other failures with high percentage in all sleeper failures are mention below, and consider primitively and automatically surveyed failures (fig1).

4. TIMBER SLEEPER FAILURES CAUSES

Fungal decay is cause with biggest percentage (53%), beside all others (fig.2). Timber is organic material and consists micro-organisms. Moisture helps fungi spreading from one sleeper to another. End splitting appears as consequence to large transverse shear loading (10%)(fig 3). Rail conection to sleeper also can provide splitting over time. Termite attacks causes permanent damage (7%). Sleeper treated with creosote is not protected from termites [3].
According to sleeper degradation, timber sleepers could be classified on sleepers in use but in good condition, sleepers for regeneration, and almost totally or totally damaged. The second ones require some methods for regeneration, according to kind of damage. The third ones have to be removed permanently or moved on the other track with less loadings [4].

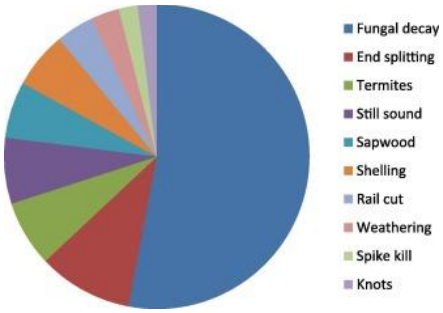

Fig.1. Causes of timber sleeper failures [3]

There is a problem appearing with a last class of damaged sleepers need to be strenght with fibre composite wraps or replaced.

Fig.2. Appearance of fungal decay

Fig.3. End-splitting of timber sleeper

Second type of sleepers, classified as regenerative, meet some ruquirement, so can be returned back on railroad. Timber sleepers' dimensions consider certain conditions like:

- upper side of sleeper must be enough wide for required width of basis plate,
- lower side also need to satisfied necesery dimensions, so can carry over loads to gravel,
- sleeper height must be enough to provide necessary resistant moment , although sleeper could have dacay and wearing traces,
- the length of wooden sleeper is determined from condition that elastic line of sleeper under rail is horizontal.

Besides mentioned reqiirements, it is necessary to calculate maximum bending moments for appropriate vertical loadings.

5. STRAIN CONTROL OF TIBMER SLEEPER

Important factor for timber strain control is size of pressure loaded from rail to timber. This pressure is not transferred hundred percent to timber. Rail is treated like continuous element with elastic reliances. Acording to this, final force transferred from axle to timber shood be calculated:

$$Q = \beta \cdot P$$

$P - axle\ load$
$\beta = 0{,}8\ \ - coefficient\ (includes\ \ dynamic\ effects)$

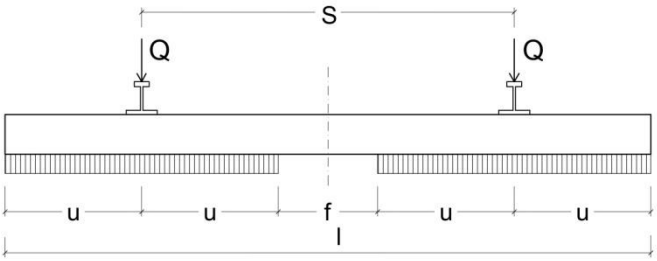

Figure 4. Stable loading scheme

Maximum value of bending moment is determined following fig.5.

$$M = \frac{Q}{2}\left(\frac{u}{2} - \frac{d}{4}\right) = \frac{Q}{8}(a - s - d)$$

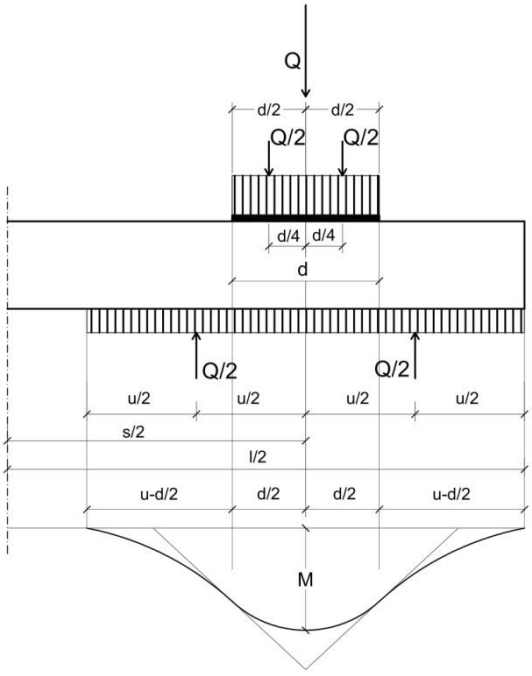

Figure 5. Review of loadings and moments on timber sleeper

$$\sigma_{ts} = \pm\frac{M}{W_{ts}} \leq \sigma_{per,ts}$$

6. METHODS FOR SLEEPER FAILURES MINIMIZING

Timber sleepers could be saved from too early degradation with performing special treatments. For fungal decay and termite attacks are possible with impregnation with synthetic chemicals and biological protection techniques. Environmental associations do not approve routine use of toxic chemical as creosote. This practice is hundreds years old [8]. It is recommended to use biological wood protection methods, in accordance with environmental regulations. Biological wood protection is possible by using live microbes or their spores. Small amounts of microbes applied onto material. Moisture helps them propagating and suppres degrading microbes. Biocontrol of wood operate with the major differences arising from the specific microbes. Fungal antagonistic against wood-degrading fungi usually tolerate a large variety of conditions and produce antimicrobial compounds during their life cycle. They may themself affect the appearance of the materials. Bacteria remain alive on wood for extended periods of time in varying conditions and can produce anti-fungal compounds, but do not cause considerable changes to wood. Viruses against wood-degrading microbes have largely remained ustudied [10]. Protection methods for fungal decay are corresponding to protection for termite attacs.
End-splitting of timber appears as separating one part of timber from another. This problem is solvable if separation is less than 20mm for sleeper's length 250mm. In this case end-plates could stop splitting. This type of failure can be determined due to automatic monitoring with all details and classification. Other failure causes of sleeper, because of it's small participation, are not further mention in this text [3].

7. CONCLUSION

According to types of failures, determined by any way of monitoring, there is real need for failures prevention. Researches noticed how significant is to indicate on dangerous treatment in timber sleeper industry. They proved there is equal replacement for toxic materials to provide best sleepers results. Prevention of microbial degradation has economical and environmental impact, but not yet reached a technical level for large scale commercial production.
Replacement is the best way for track refinement, but also the most expensive. Protective measures give satisfactory results for lower price. It is obvious, sometimes is not possible to prevent some consequences, especially caused by high loadings. The high maintenance costs and environmental problems of timber, concrete and steel sleepers created ideas for alternative materials. There are alternatives for concrete and steel sleepers in a way of composite sleepers. This gives a chance to ecological programs for hazardous waste background. Their utilization is very slow and there is not long standing experience. Further experiment should be based on monitoring and anticipation of composite railway sleeper behavior in track. This is the only way to recognize its disadvantages and improve it, so composite sleepers would be worthy replacement for timber sleepers.

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КОНТРОЛА И АНАЛИЗА СТАЊА ДРВЕНИХ ПРАГОВА

Резиме: *Железнички прагови су неизоставни елемент на железничкој прузи. Њихова функција је вишеструка. Дрвени прагови спадају у најчешће коришћени прагови. Након употребног века, не задовољавају експолатационе потребе. Јако је важно, у процесу експлоатације, пратити величину осовинског оптерећења и проверавати носивост прагова за то време. Трошкови одржавања дрвених прагова интензивно расту последњих година. Контрола дрвених прагова је дуго вршена примитивним системима од стране обучених оператера. Ово временом постаје превише захтевно, услед потребе за изузетно обученим кадром. Механизована контрола стања прагова подразумева поуздане методе и процедуре за испитивање стања прагова, без оштећења истих. Овим системом се врши снимање, анализа и класификација евентуалних оштећења прагова. Посебну пажњу треба обратити на утврђивању узрока ошећења и њиховом евентуалном спречавању или бар убрлажавању. На тај начин би се трошкови одржавања значајно смањили. Треба се позабавити појавом трулежи, досадашњим и савременим системима заштите дрвета, као и биолошки прихватљивијим средствима заштите. Потпуно уништене прагове треба прописно одложити у складу са могућностима и захтевима за очување животне средине. Као адекватна замена за дрвене прагове се јављају прагови од бетона и челика. У новије време се помињу и прагови од композитног материја, али њихова примена није у потпуности оправдана досадашњом употребом.*

Кључне речи: *дрвени праг, мониторинг, одржавање прагова, композитни пагови, биолошка заштита прагова*