T.C.
ERCİYES ÜNİVERSİTESİ
BİLİMSEL ARAŞTIRMA PROJELERİ
KOORDİNASYON BİRİMİ

ZEKİ HEMZEMİN GEÇİT TASARIMI, PROTOTİP GERÇEKLEŞTİRİLMESİ VE KONTROLÜ

Proje No: FCD-2014-5163

Çok Disiplinli Araştırma Projesi

SONUÇ RAPORU

Proje Yürütücüsü:
Şükrü SU
Mühendislik Fakültesi / Makine Mühendisliği Bölümü

Araştırmacılar
Prof. Dr. Şahin YILDIRIM
Mühendislik Fakültesi / Mekatronik Mühendisliği Bölümü
Yrd. Doç. Dr. Menderes KALKAT
Niğde Üniversitesi / Makine Mühendisliği Bölümü
Arş. Gör. Çağlar SEVİM
Mühendislik Fakültesi / Makine Mühendisliği Bölümü

Ocak 2016

KAYSERİ

TEŞEKKÜR

Bu çalışmanın gerçekleştirilmesi için gerekli desteği veren Erciyes Üniversitesi Rektörlüğüne ve Bilimsel Araştırma Projeleri birimine teşekkür ederiz.

İÇİNDEKİLER

Sayfa No

ZEKİ HEMZEMİN GEÇİT TASARIMI, PROTOTİP GERÇEKLEŞTİRİLMESİ VE KONTROLÜ

Dünyanın her geçen yıl nüfusu artmakta olduğundan yolcuların, özellikle güvenli ve hızlı olmasından dolayı demiryolu seyahatini tercih etmeleri kaçınılmaz hale gelmiştir. Bu sebepten dolayı, aşırı talep üzerine bazı güvenlik önlemlerinin ilerleyen teknolojik gelişmelerden dolayı, günümüzde, hemzemin geçit sistemleri, demiryolu sistemlerinin çok önemli parçaları haline gelmiştir. Kontrolsüz hemzemin geçitler; demiryolu şartları ve hızlı geçişler nedeniyle araç sürücüleri için çok büyük tehlike oluşturmaktadır. Bu çalışmada akıllı demiryolu ve geçit tasarımı ile akıllı sensör ve kontrol teknolojili analiz hakkında bir araştırma yapılmıştır. İlk olarak, bütün şartlar sağlanarak ve araçlar kullanılarak prototip tasarlandı. İkinci olarak ise; sistemin prototipi tasarlanmış şartlara göre kuruldu. Tren sistemi farklı çalışma hızlarında test edildi. Bununla birlikte, sistemin titreşimleri farklı çalışma hızları için analiz edildi. Diğer taraftan ise, geçidin kapanış ve açılış süreleri, demiryolu sistemlerinin farklı hızlarına göre değişmektedir. Demiryolu Hemzemin Geçidi kazaları ender görlen bir olay olarak kabul edilse de etkisi genellikle şiddetlidir. Zira Demiryolu Hemzemin Geçidi güvenlik sistemleri karmaşıktır ve en az iki taşımacılık modunu ele alırlar. İş güvenliği mühendisliğinin temel kavramının parçaları olan; mühendislik altyapısı, hemzemin geçidi çevreleyen ortam ve insan faktörleri de model içinde değerlendirilecektir.

***Anahtar sözcükler: demir*-yolu hemzemin geçidi, tren sistemi, titreşim analizi**

DESIGN OF INTELLIGENT LEVEL CROSSING, PROTOTYPE IMPLEMENTATION AND CONTROL

Due to increased population in the world, it is necessary to prefer railway travelling for passengers. Nowadays, rail-way crossing system are very important parts of railway systems. Uncontrolled railway crossing; it becomes very dangerous for car drivers; because of railway conditions and fast passing. In this study, intelligent railway and crossing design and analysis with intelligent sensor and control technology was made a research. Firstly, the prototype were designed with all instruments and conditions. Secondly; the prototype of system was set-up as designed conditions. The train system was tested with different working speeds. However, the system's vibrations were analyzed for different working speeds. On the other hand the closing and opening times were changed with different speeds of railway systems. Even though Railway Level Crossing accidents can be considered as a rare event, the impact is often severe. Since Railway Level Crossing safety systems are complex and dealing with at least two transport modes. The components of basic concept of safety engineering; engineering infrastructure, level crossing surrounding environment and human factors will be also considered in the model.

Key words:rail-way crossing, railway systems, vibration analysis

1.GİRİŞ

Teknolojik gelişmelere rağmen; ülkemizde özellikle hemzemin geçitlerin iyileştirilmesine ve geliştirilmesine yönelik çalışmalar çok iyi düzeyde değildir. Bundan dolayı, maddi ve can kayıplı hemzemin geçit kazalarının önüne geçilememektedir. Bu proje çalışmasında; akıllı hemzemin geçit sistemi üzerine tasarım gerçekleştirilmiş, uygulamalı olarak; mekatronik sistem özelliğine sahip bir prototip sistem üzerine yoğunlaşılarak bu sistem üzerinde hemzemin geçit güvenliğine dair çalışmalar yapılmıştır. Bu çalışmada sensör teknolojisi ve kontrol uygulaması ile geliştirme yapılmış, prototip sistem farklı çalışma hızları ve farklı yükleme şartları için test edilerek hemzemin geçit bariyerlerinin trenin hızına göre kapanması sağlanmış, böylece hemzemin geçitlerde meydana gelen zaman kaybı azaltılmaya çalışılmıştır. Ayrıca; laboratuvarımızda mevcut olan; titreşim ölçüm sistemi ile gerçek zamanlı ivme ve gürültü etkileri de sistem üzerinden farklı çalışma hızları ve yükleme şartları için elde edilmiştir.

2.GENEL BİLGİLER

Karayolu ile demiryolunun aynı zemin üzerinde olduğu ya da birbirlerini aynı düzede kestikleri eş düzey geçitlere “Hemzemin Geçit” denir. Hemzemin geçitlerin, trenin gelişi sırasında güvenli bir biçimde kapanmasını sağlamak insan hayatı açısından önemli bir yere sahiptir.

Şekil 1. Hemzemin Geçit

Hemzemin geçitler, kullanım alanlarına ve imkanlarına göre farklı farklı sınıflandırmalara sahiptirler. Genel olarak;

- Bariyersiz-Bekçisiz Hemzemin Geçitler
- Bariyerli-Bekçili Hemzemin Geçitler
- Bariyerli-Otomatik Hemzemin Geçitler

şeklinde sınıflandırılabilirler. Şekilde 1’de beriyerli-bekçili hemzemin geçit görünümü verilmiştir. Günümüzde kullanılan bariyerli-otomatik hemzemin geçitlerde ise, geçitten 1.5 km uzaktaki ve diğer raylardan izole edilmiş, iki raya + ve - kutup kabloları bağlanmaktadır. Tren bu iki rayın üzerinden geçtiği anda anahtar vazifesi görerek devreyi tamamlamaktadır. Böylece hemzemin geçit sisteminde öncelikle ışıklı ve sesli uyarı sistemleri çalışarak, bu sistemlerin çalışmasından on saniye sonra hemzemin geçit bariyerleri kapanmaktadır. Fakat raylara bağlanan bu kutup kablolarının açıkta olması, güvenli bir şekilde bağlanmaması, kopma tehlikesi olması büyük bir risk arz etmektedir. Kutup kablolarının bağlantı yeri ile elektrik panosu arasında kabloların tehlike biçimde açıkta olması sistem için büyük tehlike arz etmektedir. Eğer kutup kablolarından birisi herhangi bir nedenle kopacak olursa; tren gelişi sırasında anahtarlama vazifesi göremeyecek ve sistem trenin geldiğini algılayamayacağı için büyük kazaların oluşması kaçınılmaz olacaktır. Bu sebepten dolayı bariyeri kapatacak sistemin güvenli ve arıza eğiliminin minimum düzeyde olması gerekmektedir. Bu amaçla, bu projede mevcut mekanik sistemlere entegre edilebilecek kompakt ve güvenli bir sistem geliştirilmiştir. Mevcut sistemlerin en büyük dezavantajlarından biri ise bariyerlerin kapanarak trenin hemzemin geçitten geçmesinin büyük zaman aralığında yaşanmasıdır. Tren hızı ne olursa olsun, trenin hemzemin geçite olan uzaklığı 1.5 km mesafe kalınca bariyerler kapanmak durumundadır. Yani trenin hızı 120 km/saat veya 10 km/saat olsa bile bariyerler aynı mesafeden kapanmaktadır ve eğer trenin hızı daha düşük ise kapalı kalma süresi daha uzun olmaktadır. Buda hemzemin geçitte bekleyen sürücüler için büyük zaman kaybına yol açmaktadır. Hemzemin geçitte trenin geçmesini beklerken çoğu sürücü sabırsız davranarak bariyerleri çaprazlama şeklinde geçmeye çalışmakta ve can kayıplarının olduğu büyük kazalar meydana gelmektedir. İstatistiki veriler incelendiğinde, ülkemizde hemzemin geçitlerde oluşan çarpışmaların demiryolu kazaları içinde önemli bir yer tuttuğu görülmektedir. 2001-2011 yılları arasında oluşan tüm demiryolu kazalarının ortalama %35'i hemzemin geçit kazası şeklinde meydana gelmiştir. 2010 yılından itibaren hemzemin geçitlerde yapılan iyileştirmelere rağmen hemzemin geçit kazalarının toplam demiryolu kazaları içindeki oranı ancak %20 lere kadar düşmüştür. Aşağıda Türkiye Cumhuriyeti Devlet Demir Yollarının hazırladığı istatistik yıllıklarından alınan verilerle oluşturulmuş tablolar verilmektedir. Tablo 1'de yıllara göre demiryollarında yaşanan kaza sayıları ve hemzemin geçit kazalarının toplam kazalardaki payı gösterilmiştir. Tablo 2'de ise yıllara göre hemzemin geçit kazalarındaki ölüm ve yaralanma sayıları verilmiştir. [1]

Tablo 1. Demiryollarında yaşanan kaza sayıları ve hemzemin geçit kazalarının toplam kazalardaki payı [1]

YILLAR	**Toplam Kaza Sayısı**	**HG Kazaları Sayıları**	**HG Kazaları (%)**
2001	636	246	38,68
2002	478	189	39,54
2003	556	197	35,43
2004	555	214	38,56
2005	522	194	37,16
2006	455	157	34,51
2007	394	139	35,28
2008	386	118	30,57
2009	299	85	28,43
2010	194	46	23,71
2011	177	42	23,72

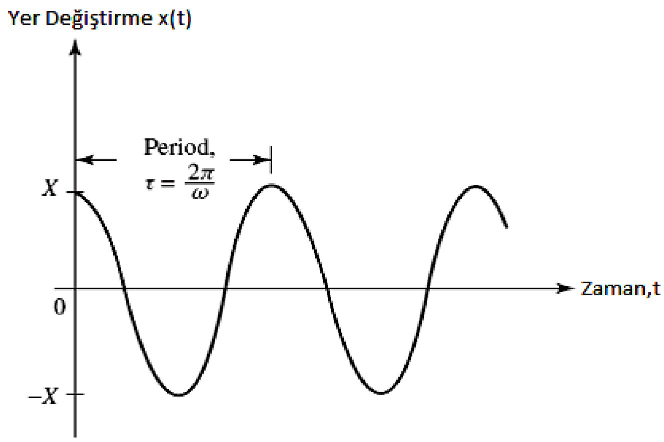
Tablo 2. Yıllara göre hemzemin geçit kazalarındaki ölüm ve yaralanma sayıları [1]

İŞLETME KAZALARI	**2007**	**2008**	**2009**	**2010**	**2011**	
Hemzemin Geçit Kazaları	139	118	85	46	42	
Ölü Sayısı	43	37	38	25	36	
Yaralı Sayısı	143	114	203	64	61	

Yapılan bu proje çalışması akıllı titreşim algılama ve kontrol sistemler içerdiğinden özellikle bir bekçi veya operatör bulunması zorunluluğunu ortadan kaldırmış tam otomatik ve akıllı bir sistem ortaya koymuştur.

Titreşim konusu literatürde çok fazla araştırılmış ve halen geçerliliğini koruyan bir konudur. Titreşim, cisimlerin sabit bir referans eksene veya nominal bir pozisyona (denge konumu) göre tekrarlanan hareketi olarak ifade edilir. Bu salınımlar bir sarkacın hareketi gibi periyodik olabileceği gibi çakıllı bir yolda tekerleğin hareketi gibi rastgele de olabilir. Titreşim her yerde mevcut olan ve mühendislik tasarımlarının yapısını etkileyen bir olgudur. Titreşim karakteristikleri mühendislik tasarımları için belirleyici faktör olabilir. Titreşim bazen zararlı olabilir ve kaçınılmalıdır, bazen de oldukça yararlıdır ve istenilir. Her iki durumda da titreşimin nasıl analiz edileceği, ölçüleceği ve kontrol edileceği mühendislik için önemli bir bilgidir. Titreşim teorisi cisimlerin ve ilgili kuvvetlerin salınımlı hareketleri ile ilgilenir. Şekil 2'de görülen salınımlı hareket, harmonik hareket olarak adlandırılır ve aşağıdaki formül ile ifade edilir. [2]

$x(t) = x \cdot Cos(w.t)$



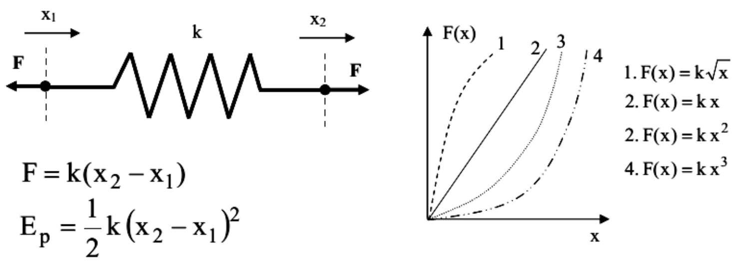
Şekil 2. Basit Harmonik Hareket

Burada "x" hareketin genliği, "ω" hareketin frekansı ve "t" zamandır. Titreşim olayı potansiyel enerjinin kinetik enerjiye, kinetik enerjinin ise potansiyel enerjiye dönüşümünü içermektedir. Bu nedenle titreşim yapan sistemler potansiyel enerji ve kinetik enerji depolayan elemanlara sahip olmalıdır. Potansiyel enerji depolayan elemanlar yay veya elastik elamanlar, kinetik enerji depolayan elemanlar ise kütle veya atalet elemanlarıdır. Elastik elemanlar potansiyel enerji depolar ve bu enerjiyi atalet elemanına kinetik enerji olarak geri verir.[2]

Titreşim yapan sistemlerin analizi için ilk olarak sistem yapısını yeterli derecede ifade edecek içerikte bir matematik model oluşturulur. Oluşturulan model sistemin temel titreşim hareketlerini yeterli yaklaşıklık ile ifade edilecek nitelikte basitleştirmeler içerebilir. Matematik model oluşturulurken titreşim sisteminde bulunan elemanların lineer veya lineer olmayan özellikleri belirtilir. [5]

Titreşim yapan sistemlerde potansiyel ve kinetik enerji depolayan elemanlar ile sönümlü sistemlerde enerji sönümünü sağlayan elemanlar mevcuttur. Bu elemanlara ait denklemler aşağıda verilmiştir.

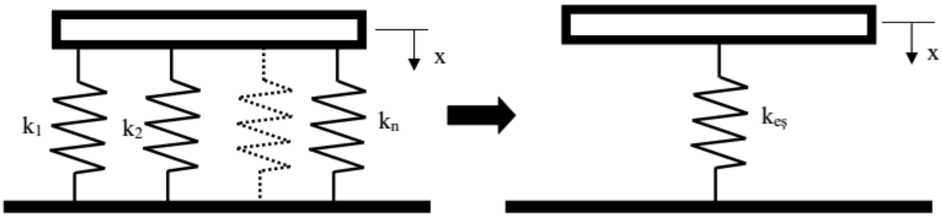
Elastik Elemanlar (Yaylar): Yaylar titreşim sistemlerindeki kütleleri birbirine bağlayan ve kütlelerin bağıl hareketlerini sağlayan elemanlardır. Yaylar lineer ve nonlineer karakteristiğe sahip olabilirler. Lineer karakteristiğe sahip yaylar Hooke yasasına uygun davranırlar ve yayda oluşan elastik kuvvet yaydaki şekil değişimi ile orantılıdır. Fakat titreşim genliklerinin yüksek olduğu zaman ve/veya metal olmayan malzemeler kullanıldığında yaylar lineer davranışa sahip olmayabilirler. Şekil 4' te bazı yay karakteristikleri gösterilmiştir. [2]



Şekil 4. Yay Karakteristiği

Titreşim yapan mekanik sistemlerde potansiyel enerji depolayan esnek elemanların paralel ve seri olmak üzere farklı konfigürasyonları bulunabilir. Bu durumlarda eşdeğer direngenliklerin elde edilmesi gereklidir. Seri ve paralel bağlantı durumları için eşdeğer hesapları aşağıdaki gibi ifade edilir.

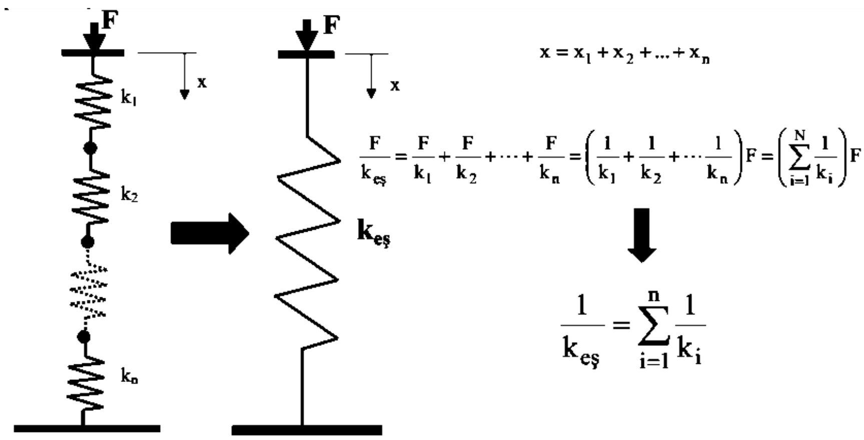
Paralel Bağlantı: Bir mekanik sistemde paralel yay konfigürasyonu söz konusu ise eşdeğer yay katsayısı şu şekilde hesaplanabilir



Şekil 5. Eş Değer Yay Gösterimi

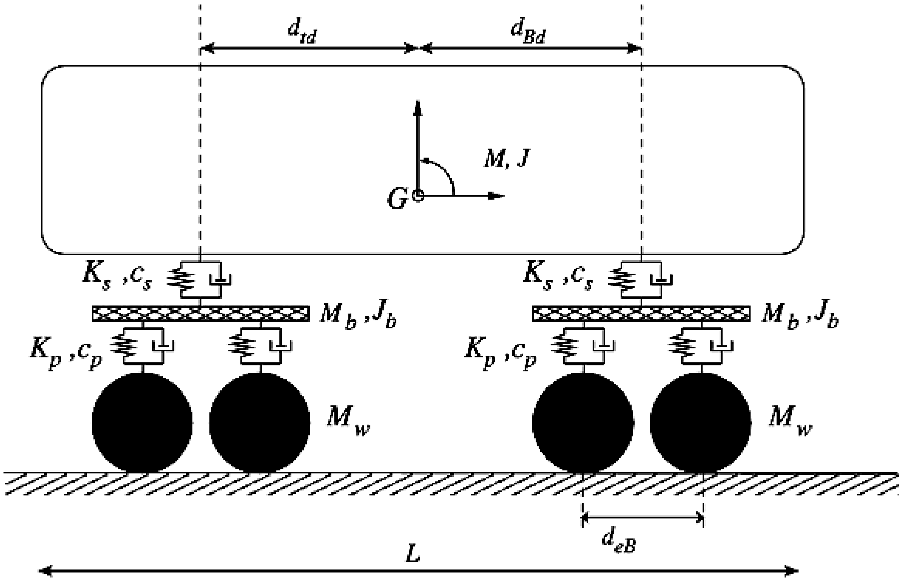
$$\sum_{n=1}^{n} F = k_1x + k_2x + \cdots + k_nx = (k_1 + k_2 + \cdots + k_n)x = \left(\sum_{n=1}^{n} k_i\right).x = k_{eş}.x$$

Seri bağlantıda tüm yaylardaki kuvvet aynı olup toplam çökme tüm yaylardaki çökmelerin toplamına eşittir. [2] Şekil 6'da seri bağlı yayların gösterimi verilmiştir.



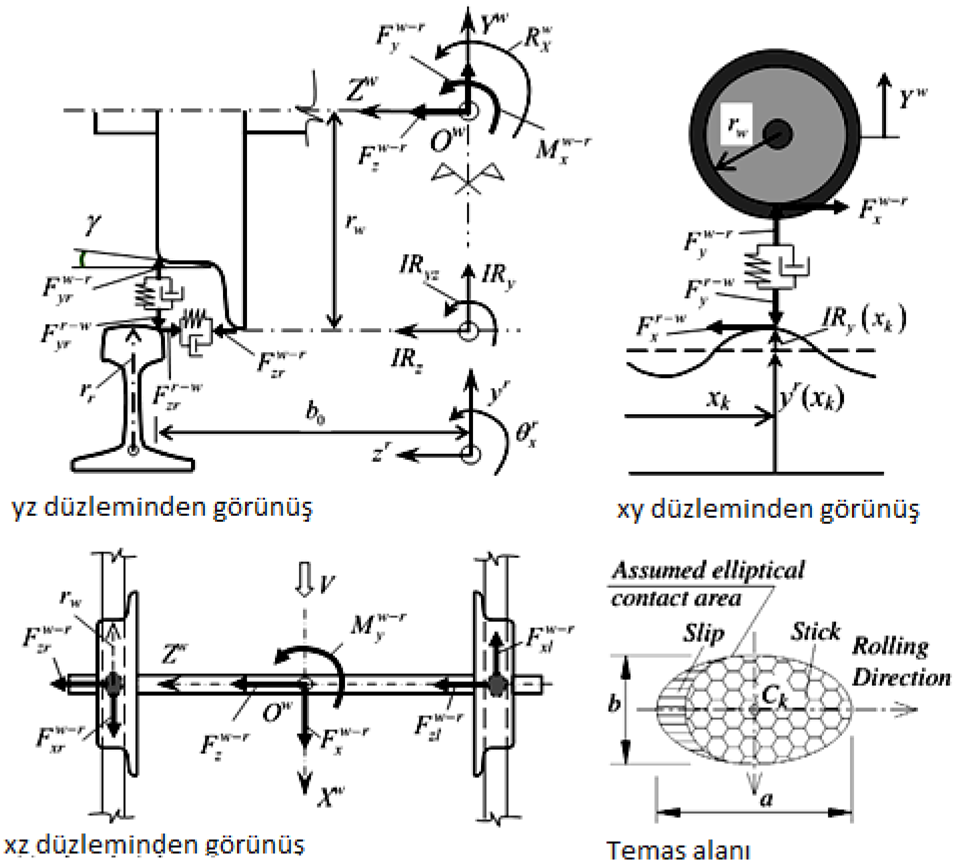
Şekil 6. Seri Bağlı Yayların Gösterimi

Bir tren vagonunun modellenmesi ise, vagon kütlesi M olmak üzere Şekil 7' de verilmiştir. Burada vagon gövdesi ve teker sistemleri arası ilişki, sönüm elemanları ve yay elemanları ile modellenmiştir.



Şekil 7. Bir Tren Vagonunun Titreşim Modeli [8]

Bir tren vagonu ve raylar arasındaki temas ilişkisine ait titreşim modeli ise Şekil 8'de verilmiştir.



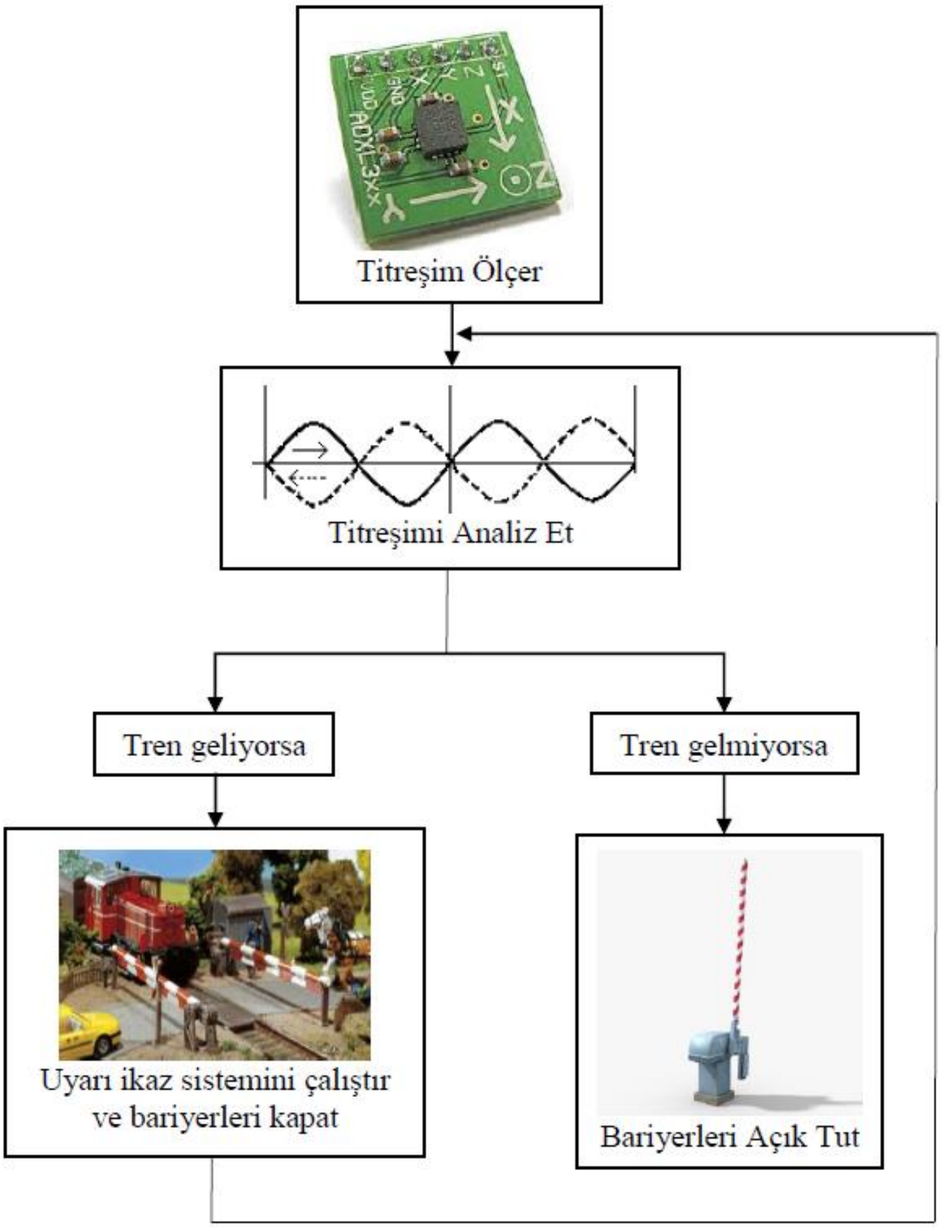
Şekil 8. Teker-Ray İlişkisinin Titreşim Modeli [7]

3.GEREÇ VE YÖNTEM

Bu çalışmada, günümüzde uygulama alanı oldukça genişleyen ve hızla kullanımı yayılan ARDUINO sistemi ve bu sistem ile uyumlu sensörler kullanılmıştır. Arduino çevresiyle kolay bir şekilde etkileşime girebilen bir sistemdir. Kendi üzerinde bulunan mikro denetleyici kolay bir şekilde programlanarak istenilen işlemleri yerine getirmesi sağlanabilmektedir. Arduino çok geniş kapsamlı bir platformdur. Üzerinde analog ve dijital giriş-çıkışlar bulunmaktadır. Mikro denetleyici bu girişlerden alınan sinyallere göre programlanarak dijital çıkışlara istenilen komutlar verilebilmektedir. Şekil 9' da Arduino platformu görülmektedir.

Şekil 9. Arduino Platformu

Arduino platformu birçok eleman ile bağlantı yapabilmektedir. Bu çalışmada Arduino platformuna titreşim sensörü bağlanmış ve bu sensörden alınan olan verilerin karakteristikleri öncelikle bilgisayar ortamında incelenerek trenin, farklı hızlarda ve farklı yükleme şartlarında oluşturduğu titreşimlerin özellikleri belirlenmiştir. Daha sonra bu titreşim karakteristikleri Arduino ile işlenerek hemzemin geçit bariyerlerinin uygun zamanda kapanması sağlanmıştır. Yöntem aşağıdaki iş akış şeması üzerinde tanıtılmaya çalışılmıştır.

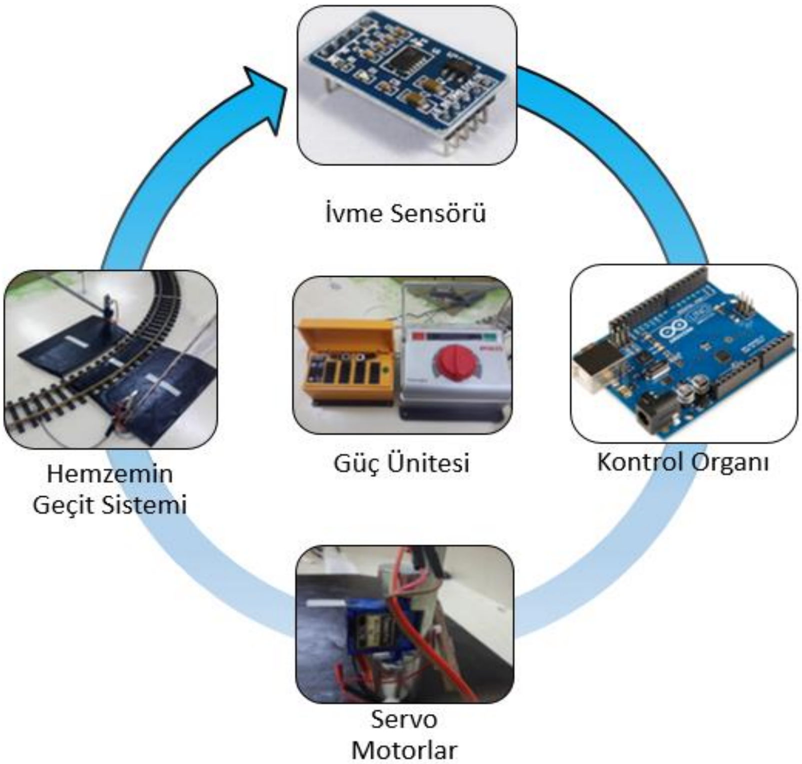


Tablo 1. İş akış şeması

Şekil 10’ da proje kapsamında alımı yapılan prototip sistemin genel görünüşü verilmiştir. Prototip sistem, gerçek sistemlere oranla 1/22.5 ölçeğindedir. Prototip tren sistemi 1 çekici lokomotif ve 3 adet vagondan oluşmaktadır.

Şekil 10. Prototip tren-hemzemin geçit sistemi

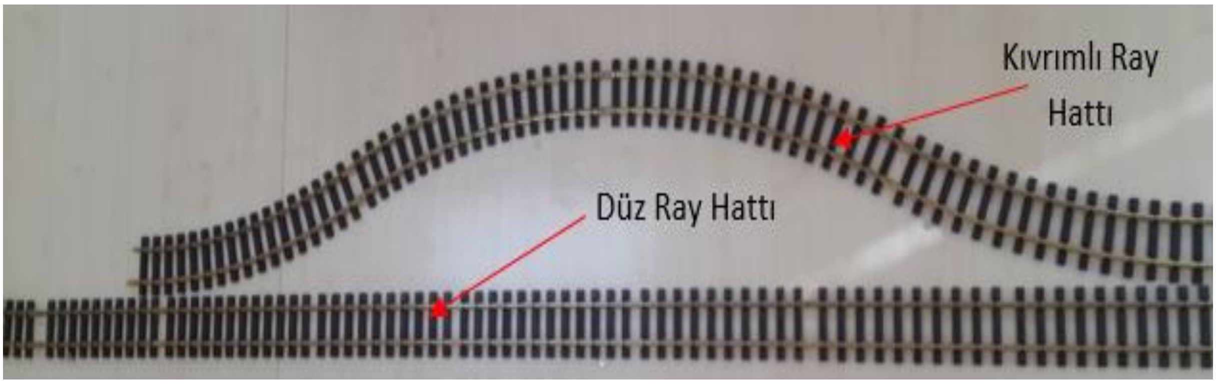
Prototip sisteminin bütün araçları Şekil 11'de resmedilen kategoriye göre çizilmiş ve ana hatlarıyla belirtilmiştir.



Şekil 11. Demir yolu hemzemin geçit sisteminin şematik gösterimi

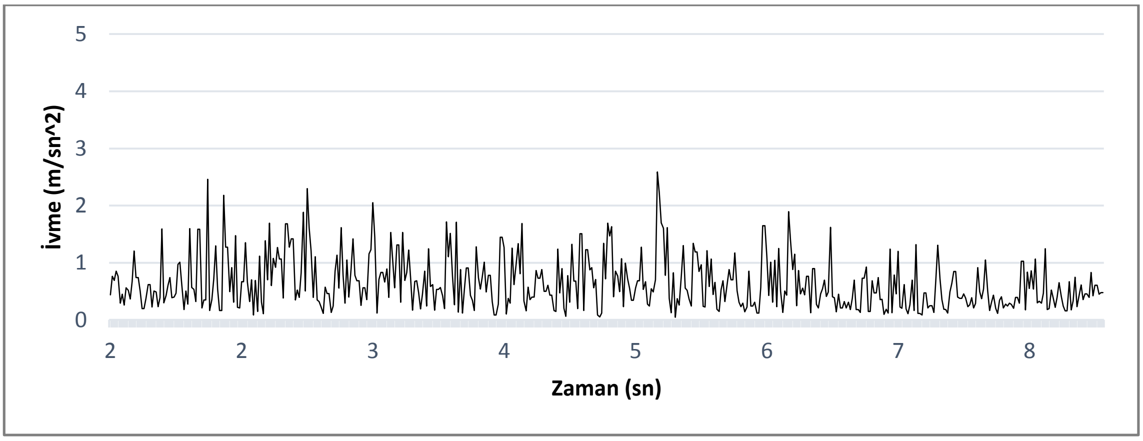
4.BULGULAR

Sistem, titreşim analizi için farklı çalışma hızları ile test edilmiştir. Sistem öncelikle Arduino ile uyumlu titreşim sensörlü ile yavaş, orta ve yüksek hızlarda ve bu hızların her biri için ise yüksüz, sadece yolcu vagonu yüklü ve hem yolcu vagonu hem yük vagonu yüklü haller için test edilmiştir. Ağırlık olarak yolcu vagonundaki her bir koltuğa, insan ağırlığını temsil etmek üzere 7 gramlık ağırlıklar konulmuştur. Hem yolcu vagonu hem yük vagonu dolu hal için ise, yük vagonuna 1.5 kg'lık kütle konulmuştur. Titreşim deneyleri 2 grupta yapılmıştır. Birinci grup, düz ray hattı, ikinci grup ise kıvrımlı ray hattı içindir. Şekil 12' de ray hatlarının görünümü verilmiştir.

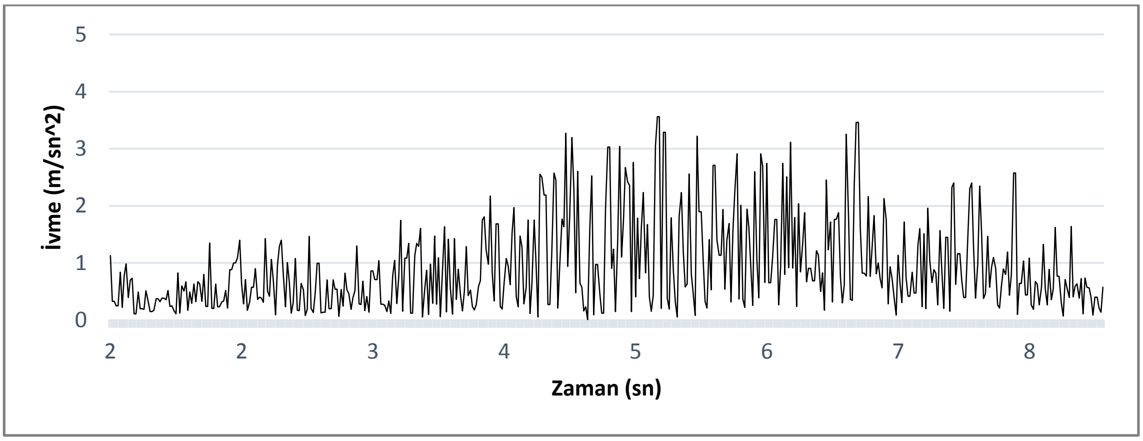


Şekil 12. Düz ve kıvrımlı ray hattı

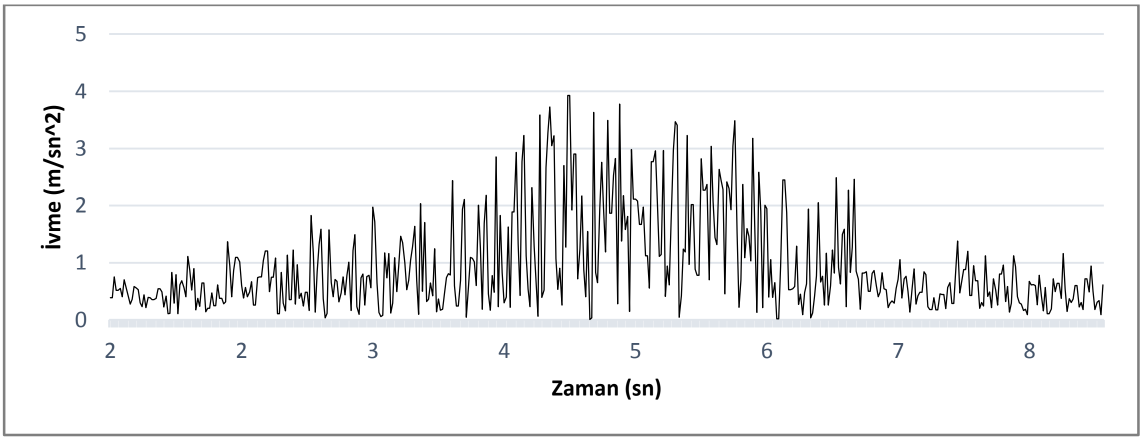
Test sonuçlarına göre Arduino programlanmıştır. Böylece Arduino trenin raylarda oluşturduğu titreşimlerin analizi yapılarak trenin hızı belirlenmiş ve hemzemin geçit bariyerlerinin bu hıza göre kapanması sağlanmıştır. Geçit bariyerleri kapanmadan önce, öncelikli olarak sesli ve ışıklı ikaz sistemleri çalışmakta ve birkaç saniye sonra geçit bariyerleri kapanmaktadır. Trenin hızı yüksek ise geçit bariyerleri hızlı bir şekilde, yavaş ise, geçit bariyerleri daha geç kapanmaktadır. Aşağıda prototip sistemin farklı çalışma şartlarına göre alınan titreşim grafikleri verilmiştir.



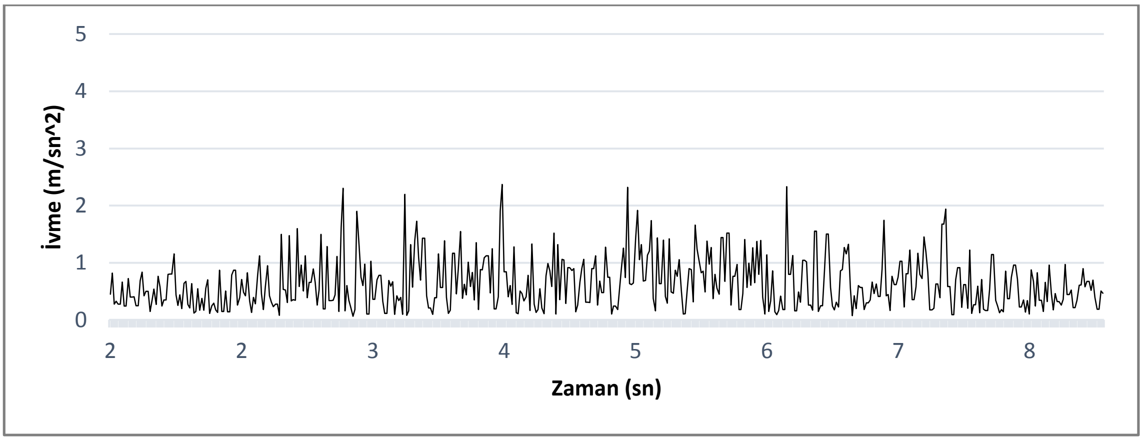
Şekil 13. Yavaş hız ve yüksüz durumda düz ray yolundaki titreşim değişimleri



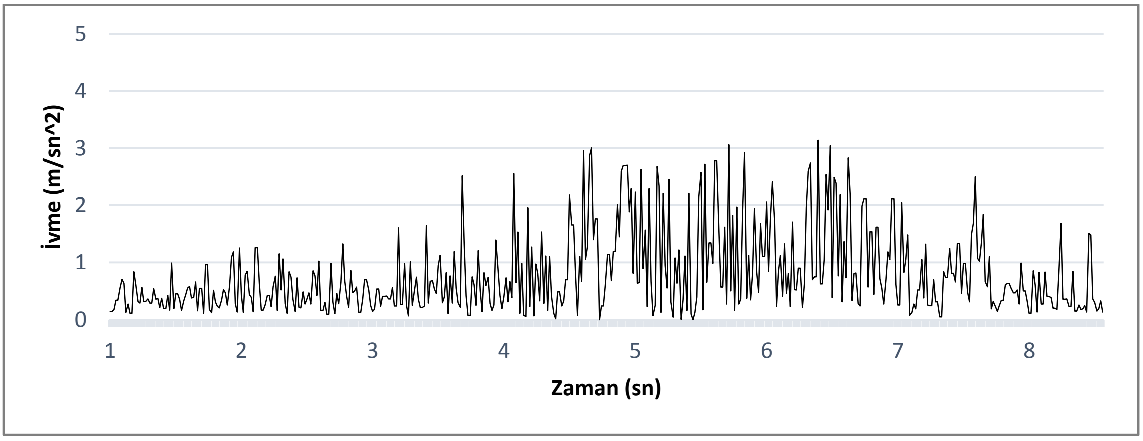
Şekil 14. Orta hız ve yüksüz durumda düz ray yolundaki titreşim değişimleri



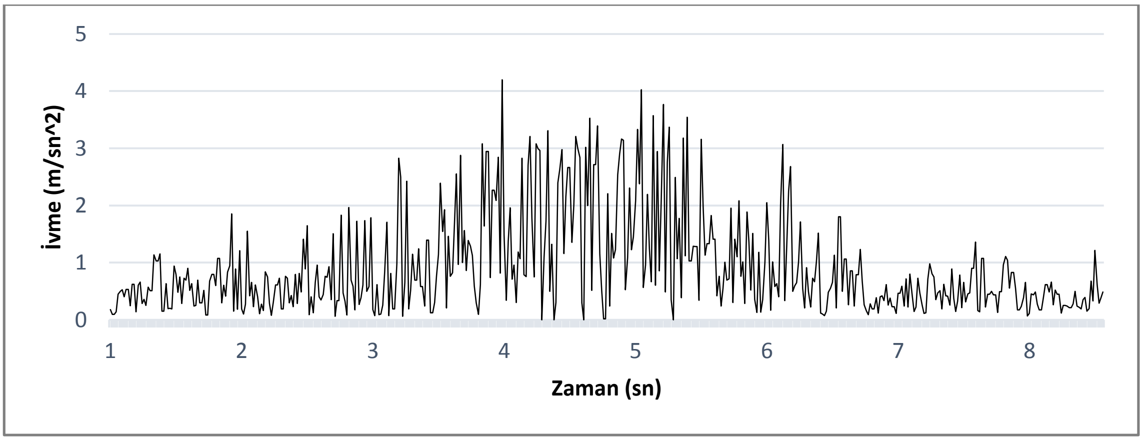
Şekil 15. Yüksek hız ve yüksüz durumda düz ray yolundaki titreşim değişimleri



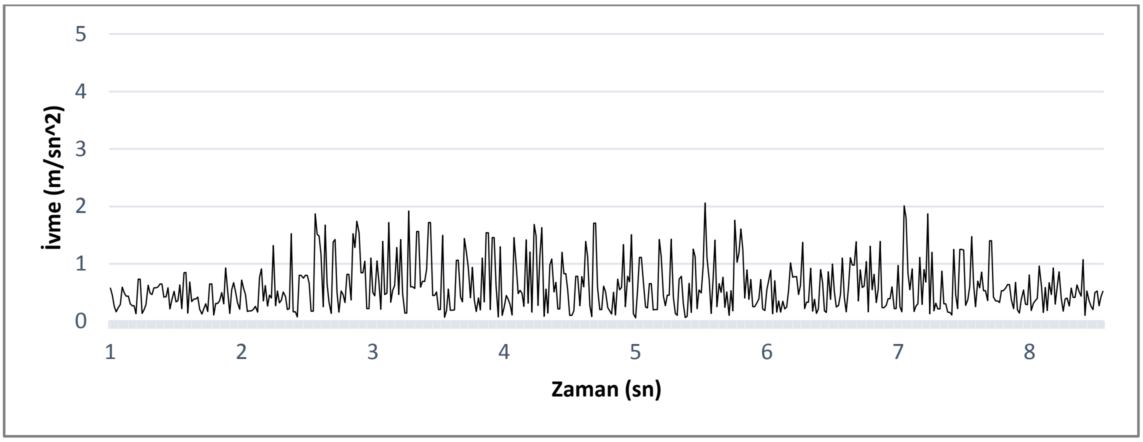
Şekil 16. Yavaş hız ve yolcu vagonu dolu durumda düz ray yolundaki titreşim değişimleri



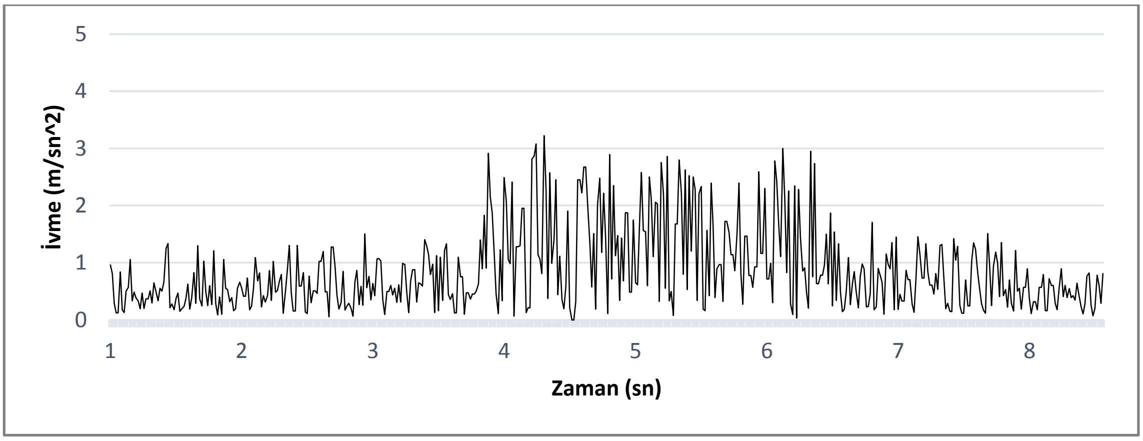
Şekil 17. Orta hız ve yolcu vagonu dolu durumda düz ray yolundaki titreşim değişimleri



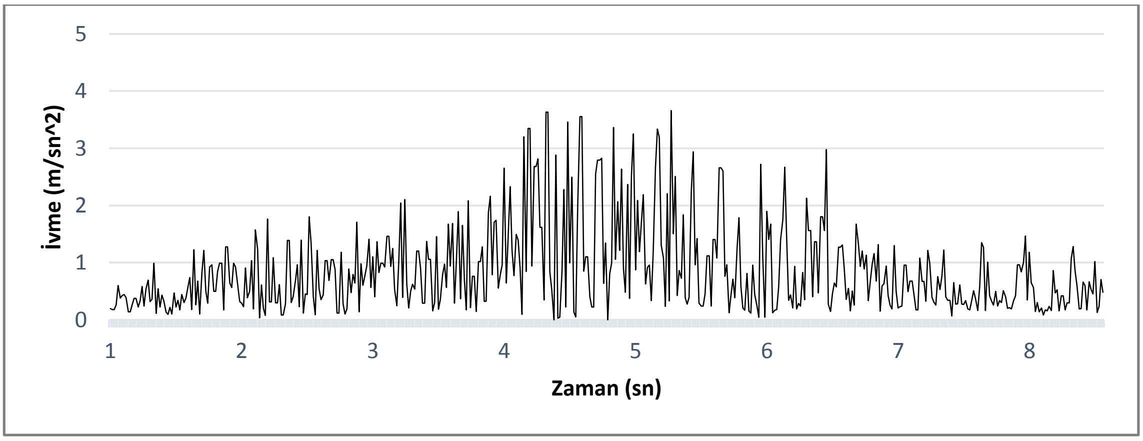
Şekil 18. Yüksek hız ve yolcu vagonu dolu durumda düz ray yolundaki titreşim değişimleri



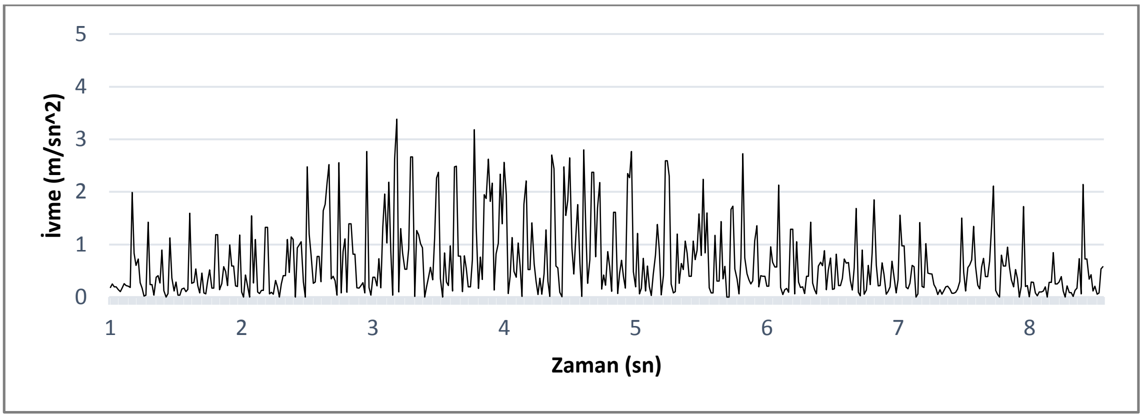
Şekil 19. Yavaş hız ve yolcu vagonu ile yük vagonu dolu durumda düz ray yolundaki titreşim değişimleri



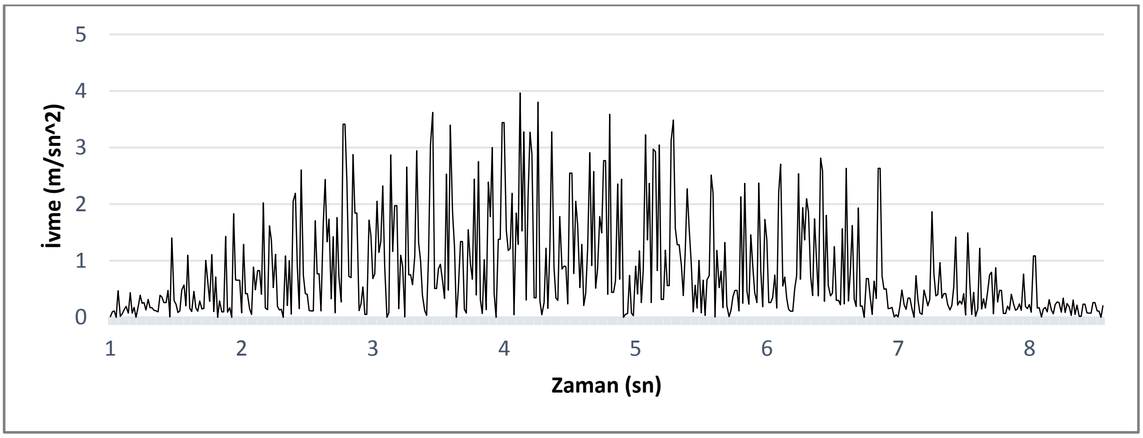
Şekil 20. Orta hız ve yolcu vagonu ile yük vagonu dolu durumda düz ray yolundaki titreşim değişimleri



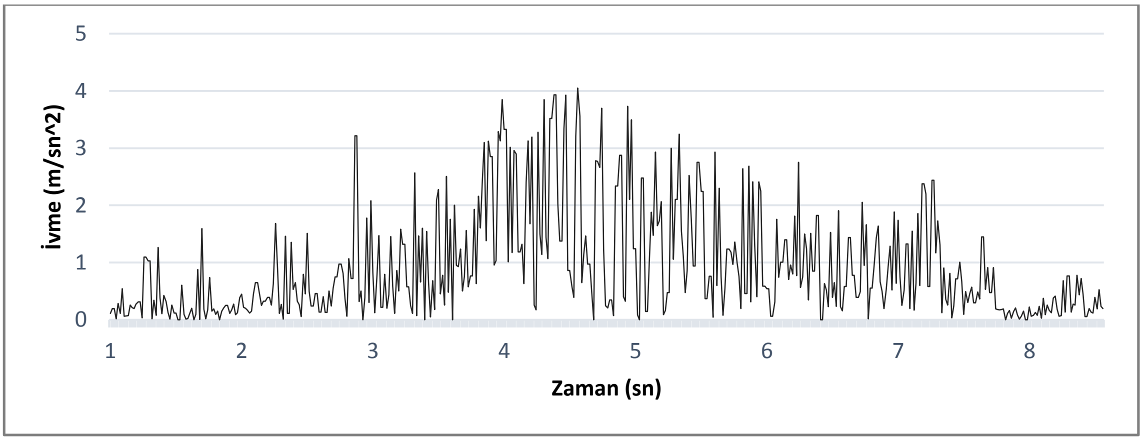
Şekil 21. Yüksek hız ve yolcu vagonu ile yük vagonu dolu durumda düz ray yolundaki titreşim değişimleri



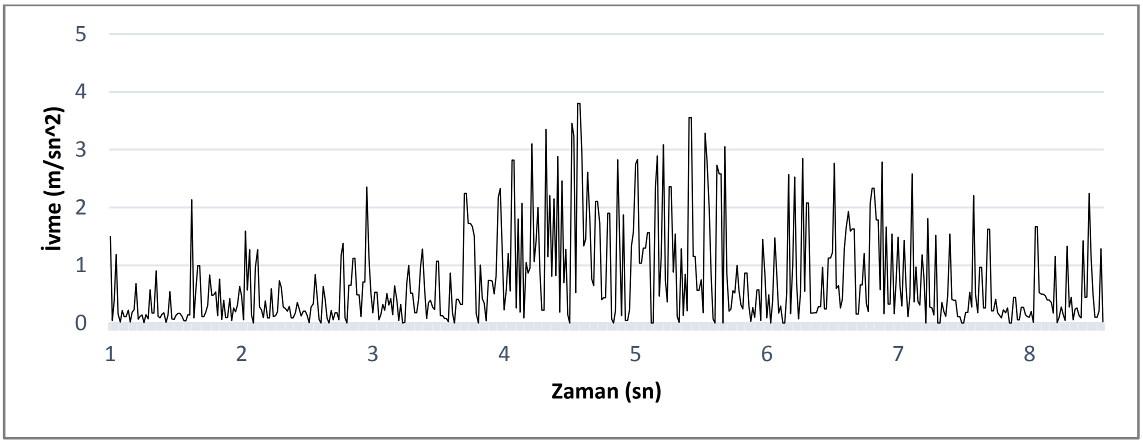
Şekil 22. Yavaş hız ve yüksüz durumda kıvrımlı ray yolundaki titreşim değişimleri



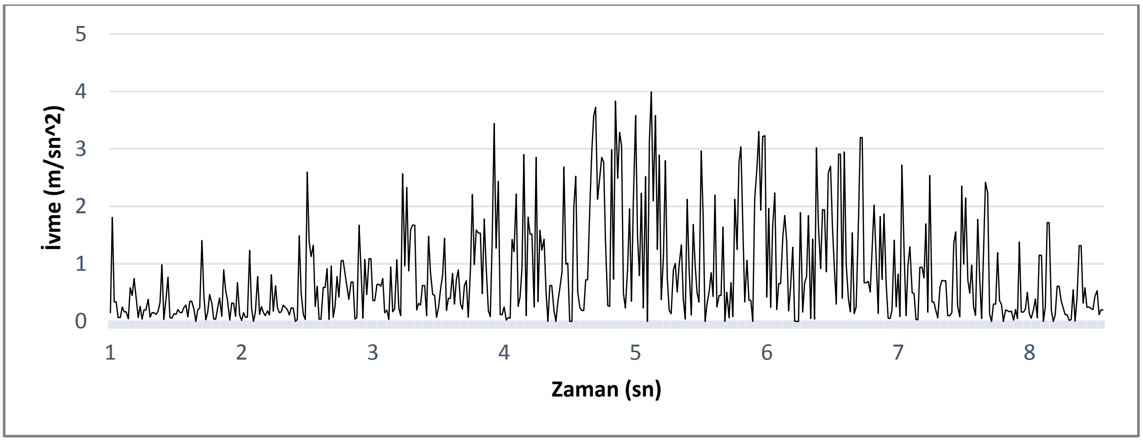
Şekil 23. Orta hız ve yüksüz durumda kıvrımlı ray yolundaki titreşim değişimleri



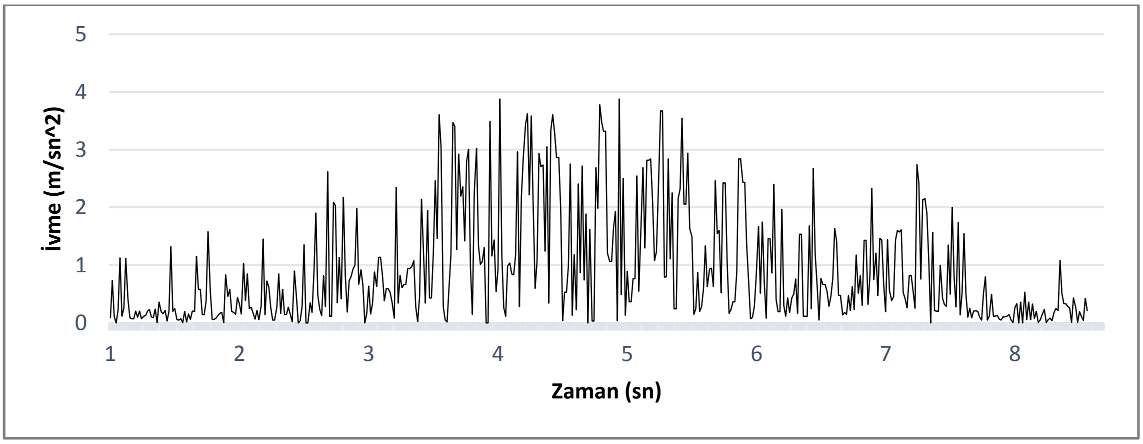
Şekil 24. Yüksek hız ve yüksüz durumda kıvrımlı ray yolundaki titreşim değişimleri



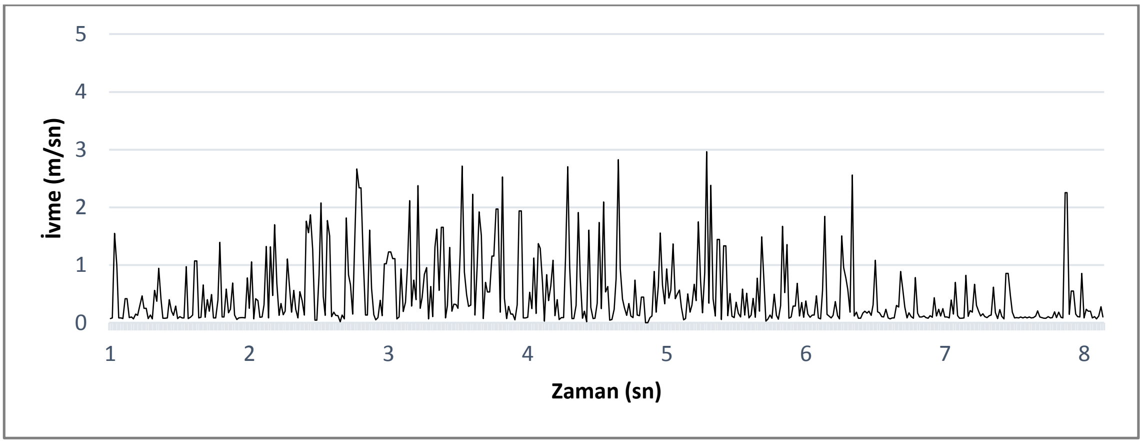
Şekil 25. Yavaş hız ve yolcu vagonu dolu durumda kıvrımlı ray yolundaki titreşim değişimleri



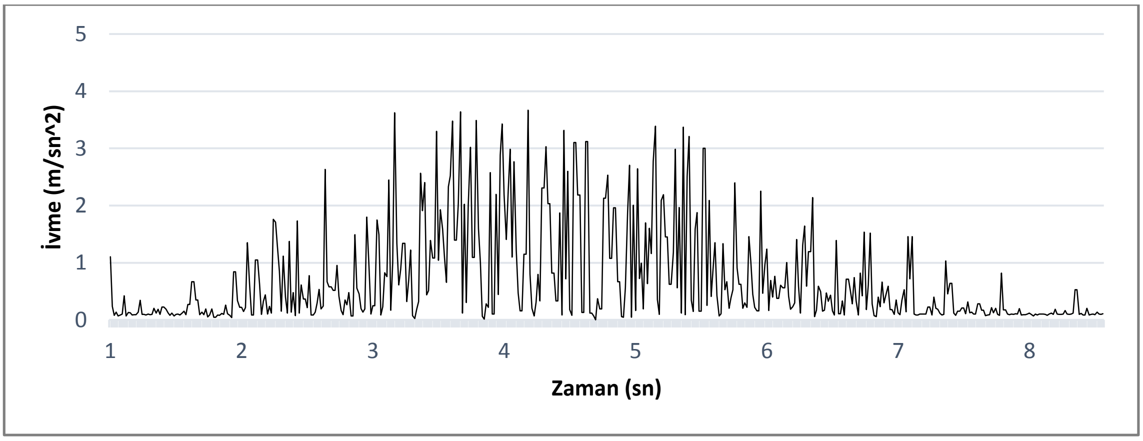
Şekil 26. Orta hız ve yolcu vagonu dolu durumda kıvrımlı ray yolundaki titreşim değişimleri



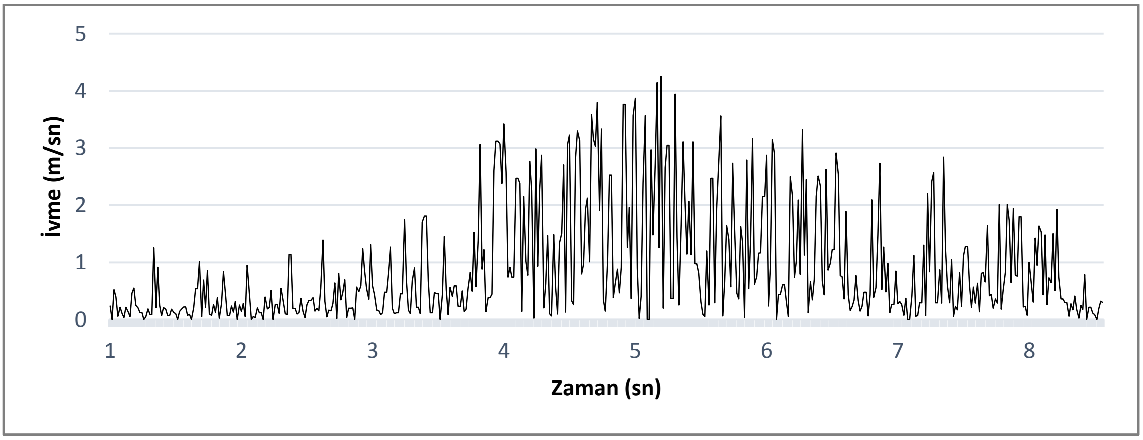
Şekil 27. Yüksek hız ve yolcu vagonu dolu durumda kıvrımlı ray yolundaki titreşim değişimleri



Şekil 28. Yavaş hız ve yolcu vagonu ile yük vagonu dolu durumda kıvrımlı ray yolundaki titreşim değişimleri



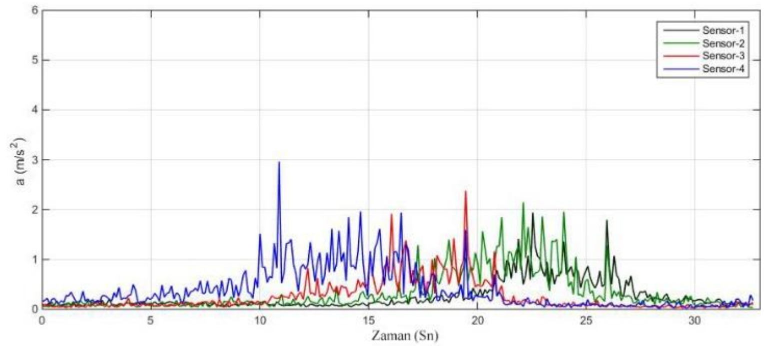
Şekil 29. Orta hız ve yolcu vagonu ile yük vagonu dolu durumda kıvrımlı ray yolundaki titreşim değişimleri



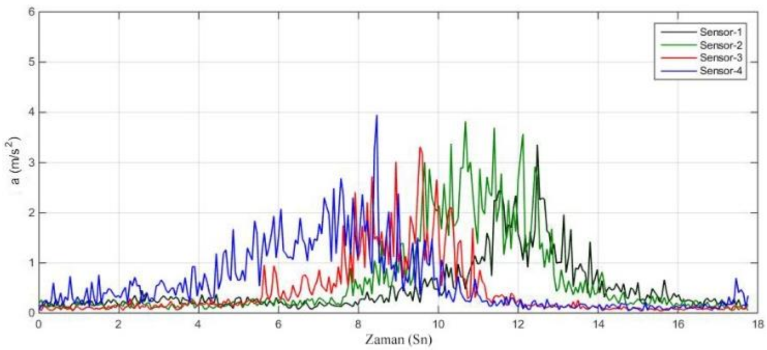
Şekil 30. Yüksek hız ve yolcu vagonu ile yük vagonu dolu durumda kıvrımlı ray yolundaki titreşim değişimleri

Ayrıca prototip sistem, Erciyes Üniversitesi Mekatronik Mühendisliği bölümünde mevcut olan 4 kanallı ivme ölçme cihazı ile de test edilmiştir. Her bir test için 4 adet aynı teknik özelliklere sahip ivme sensörleri kullanılmıştır. Bu sensörler, sistemin hemzemin geçite göre, ilk olarak sağ tarafına yerleştirilerek üç farklı hız (yavaş-orta-yüksek) için titreşim verileri alınmıştır. Daha sonra ivme sensörleri sistemin sol tarafına yerleştirilerek yine üç farklı hız için titreşim verileri alınmıştır. İvme sensörleri her iki test grubunda da tam karşılıklı olarak, hemzemin geçitin hemen yanına, viraja girme yerine, düz hat üzerine ve viraj çıkışına yerleştirilmiştir. Sağ sistemde, sol sisteme göre farklılık olarak, ikinci sensörün yerleştirildiği yerdeki rayların birleştiği noktadaki aralık biraz daha fazladır. Bu yüzden titreşim pik nokta değerleri sol sisteme göre daha yüksek çıkmıştır. Sağ sistemde üçüncü sensörün bulunduğu konumun hemen yakınında ise bir makas hattı bulunmaktadır. Bu da bütün hızlara göre titreşim pik değerlerinin, sol sisteme nazaran, daha yüksek olmasına neden olmuştur. Ayrıca bütün testlerde, hız arttıkça titreşim sıklığının artışına paralel olarak bütün titreşim sensörlerinden alınan pik nokta değerlerinde artış olduğu görülmektedir.

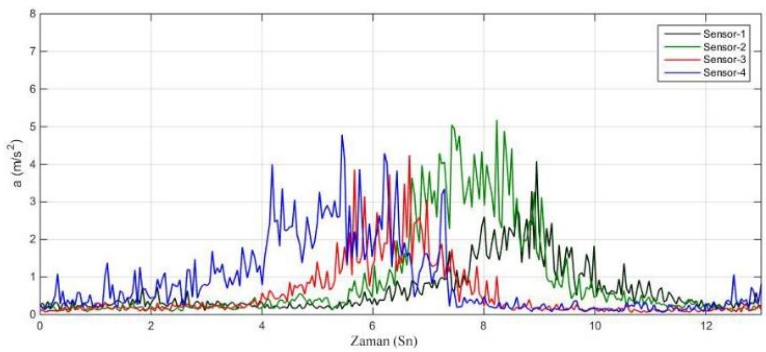
Şekil 31. Sistemin sağ tarafında ki titreşim sensörlerinin konumları



Şekil 32**.** Sistemin sağ tarafı için yavaş hızda ki ivme değişimleri

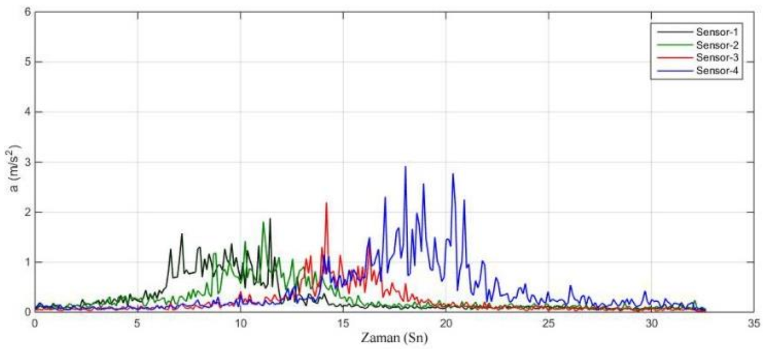


Şekil 33. Sistemin sağ tarafı için orta hızda ki ivme değişimleri

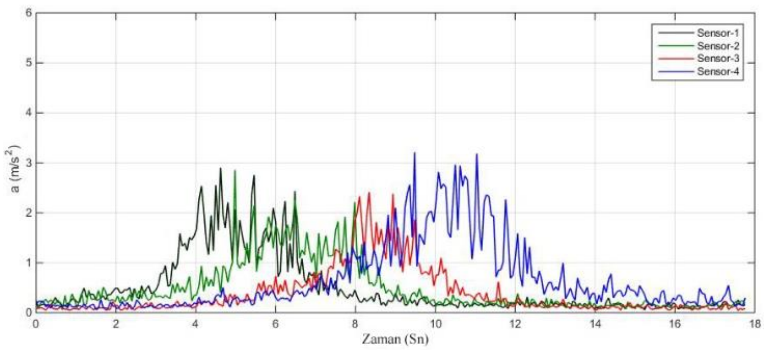


Şekil 34. Sistemin sağ tarafı için yüksek hızda ki ivme değişimleri

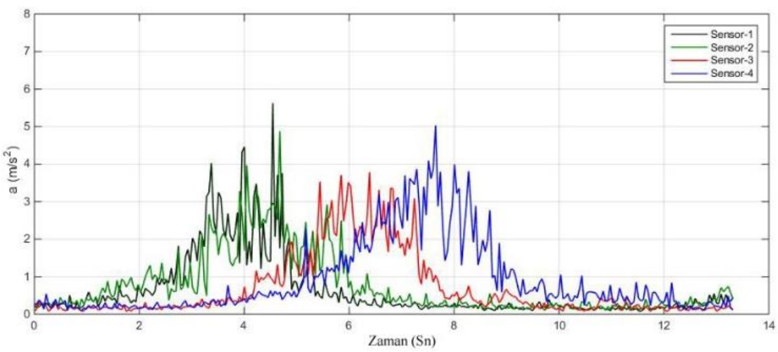
Şekil 35. Sistemin sol tarafında ki titreşim sensörlerinin konumları



Şekil 36. Sistemin sol tarafı için yavaş hızda ki ivme değişimleri



Şekil 37. Sistemin sol tarafı için orta hızda ki ivme değişimleri



Şekil 38. Sistemin sol tarafı için yüksek hızda ki ivme değişimleri

6.TARTIŞMA VE SONUÇ

Projede, hemzemin geçit bariyerlerinin, tren geçite yaklaştığı zaman, sistemin rayda oluşan tren titreşimlerini algılayarak otomatik olarak kapanmasını sağlama çalışması yenilik içermektedir. Literatürlerde hemzemin geçitlerin güvenliği ile ilgili çok az çalışma mevcuttur. Bu çalışmalar içerisinde radyo frekanslı veya treni algılayıcı sensörleri olan sistemler mevcuttur. Radyo frekanslı sisteme başka bir frekans karışması, sensörler arasına başka nesnelerin girebilme ihtimali bu sistemlerin en büyük dezavantajlarından olmaktadır. Diğer çalışmalarda ise mevcut sistemlere bazı bariyer eklemeleri veya kamera sistemi eklenmesi gibi ek güvenlik önlemleri ele alınmıştır. Fakat literatürde titreşim temelli hemzemin geçit sistemi ile ilgili herhangi bir çalışmaya rastlanmamıştır. Bu çalışmada geliştirilen prototip sistemde, mevcut sistemdeki olumsuzlukların ve yaşanan kazaların önüne geçilmeye çalışılması özgün etki olarak vurgulanabilir.

Proje kapsamında elde edilen sonuçları ve proje amacını içeren 1 adet uluslararası bildiri "International Conference on Science, Management, Engineering and Technology (ICSMET-2015) " isimli etkinlikte Mart 2015'de DUBAI 'de , 1 adet uluslararası bildiri "International Conference on Science and Innovative" isimli etkinlikte Ağustos 2015' de LIZBON'da sunulmuştur.

Ayrıca yine farklı titreşim verilerinden elde edilen sonuçlardan çıkartılan 1 adet uluslararası yayın, "International Journal of Emerging Technology and Advanced Engineering" isimli dergide Mart 2015'de yayımlanmıştır. Bildiri ve yayınlar ek'te verilmiştir.

KAYNAKLAR

1. http://www.tcdd.gov.tr/home/detail/?id=305 - istatistik yıllıkları

2. Kıral, Z., MAK 4041 Mekanik Titreşimler Ders Notları, Dokuz Eylül Üniversitesi, Mühendislik Fakültesi, Makine Mühendisliği Bölümü, İzmir

3. Theory of Vibrations-W.T.Thomson, Elements of Vibration Analysis-L. Meirovitch

4. Vibrations of Continuous Systems- S. Rao

5. Fundamentals of Mechanical Vibrations-S.G. Kelly

6. Johansson C, Simplified dynamic analysis of railway bridges under high-speed trains

7. V.N.Dinh vd , Dynamic analysis of three-dimensional bridge high-speed train interactions using a wheel rail contact model

8. J.M. Goicolea, Dynamic loads in new engineering codes for railway bridges in europe and spain

9. *S.S.Mostafa, M.M.Hossian, K.J. Reza, G.M. Rashid, A Radio Based Railway Crossing Control System to Reduce Accident, 2010*

10. J.Banuchandar, V.Kaliraj, P. Balasubramanian, S. Deepa, N. Thamilarasi, Automated Unmanned Railway Level Crossing System, 2012

11. S.Biswas, R.H.Bhuiyan, S.Hque,R.Hasan,T.N. Khan, Pressure Sensed Fast Response Anti-Collision System for Automated Railway Gate Control, 2013

EKLER

1 Adet uluslararası yayın ve 2 adet uluslararası bildiri ek olarak verilmiştir.

VIBRATION ANALYSIS OF A PROPOSED EXPERIMENTAL PROTOTYPE RAILWAY LEVEL CROSSING SYSTEM

[1]SAHIN YILDIRIM, [2]CAGLAR SEVIM, [3]SUKRU SU, [4]MENDERES KALKAT

[1,3]Erciyes University, Engineering Faculty, Mechatronic Engineering Department, Kayseri, Turkey
[2]Nigde University, Engineering Faculty, Mechanical Engineering Department Nigde, Turkey
E-mail: sahiny@erciyes.edu.tr

Abstract- As well known, commercial transports with railways are very important for secure travelling and conditions. In recent years, in spite of advanced high technology, there is still aircrafts, cars, and buses crashes in the world for travelling. Because of these reasons, it is preferable and inevitable to prefer railway travelling for passengers. Nowadays, rail-way crossing system are very important parts of railway systems for car, bus and van drivers. Uncontrolled railway crossing (URC); it becomes very big problems and dangerous for car drivers; because of railway conditions and fast passing. An investigation on intelligent railway and crossing design and analysis with intelligent sensor and control technology are outlined in this paper. Firstly, the proposed proto**type** were designed with all mechatronic elements such as instruments and conditions. Secondly; the proposed prototype of electro-mechanics system was set-up as designed conditions. However, the train system's vibration was analyzed with different working speed conditions and rail-way profiles. On the other hand the closing and opening speeds times were changed with different speeds of railway systems.

Index Terms - **Rail-Way Level Crossing**, **Train System**, **Vibration Analysis.**

I. INTRODUCTION

Moving objects crossing in front of the train may cause grade-crossing crashes. For instance, detection of obstacles (people, vehicles) crossing in front of the train will be an important potential solution.
Some researcher's results that have been investigated by other researchers. Some Railway Level Crossing (RLC) accidents is one of the major contributing factors of railway related fatality problems in many countries. In Turkey, safety issues at RLC are very serious relative to those of developing countries. However, RLC accidents have continuously become a problem in railway industries in especially when it involved fatalities. RLC is considered as a unique intersection. The systems are complex and dealing with at least two mode of transport. Therefore collision between motor vehicles and trains is likely to happen at RLC and cause catastrophic consequences [1], [2].

Safety and the operational problems at RLC can be further classified into highway and railway. The highway component comprises drivers, pedestrians, vehicles and roadway segments, whereas the train component is classified into train and track at crossing locations. The functions and characteristics of the two components and their corresponding elements represent the risk at RLC locations. Various studies have been conducted in many countries, based on a range of issues associated with safety level at RLC. Accident at RLC may be caused by a single factor or by the combination of many other factors. There is a growing realization of the need to consider contributory factors involved in accidents at RLC. Caird [3] has recommended that emphasis need to be focused on the multiple contributors to accident at RLC rather than looking at a single factor only. As in basic safety engineering studies; there are at least three basic contributing factors need to be considered. There are engineering infrastructure, level crossing surrounding environment and human factors. To address these issues, Caird discussed the angle and visibility aspects at RLC while other researchers studied factors associated with RLC due to familiarity, misjudgment and distraction. Additionally, the works of Caird [3], and Harwood [4] also argued the technical contributing factors related to the configuration and design of RLCs.
Various accident prediction equations and risk indexes were developed in order to cater for the problems at RLC. Study conducted by Saccomanno [5] revealed two basic perspectives of model developed in the United States during 1950 to 1970. Detroit Formula (1971). The US DOT model was generally recognized as the industry standard. The analysis methods used range from Multiple Linear Regressions to techniques including special statistical distributions such as the Poisson and Negative Binomial distribution [6]. However, past data is vital for analysis purposes. The lack of data in some countries is a drawback of traditional approaches and leads to leave the problem of RLC untreated [7].

II. THE PROPOSED EXPERIMENTAL ANALYSIS

Railway safety is a crucial and important aspect of rail operation the world over. Malfunctions resulting in accidents usually get wide media coverage even when the railway is not at fault and give to rail transport, among the uninformed public, an undeserved image of inefficiency often fueling calls for immediate reforms. This paper is aimed at helping the railway administrations concerned to strengthen their safety culture and develop the monitoring tools required by modern safety management. Rail/road intersections are very unique, special, potentially dangerous and yet unavoidable in the World. Here two different entities with entirely different responsibilities, domains, performances come together and converge for a single cause of providing a facility to the road user. During the normal operation also, there is every possibility of accidents occurring even with very little negligence in procedure and the result is of very high risk. The potential for accidents is made higher as the railways control only half the problem. The other half, meanwhile, cannot really be said to be controlled by one entity, as even though traffic rules and road design standards supposedly exist, the movements of road users are not organized and monitored by one specific entity as rigidly as rail movements.

For the purposes of finding obstacles systems laser sensors, radar, etc., similar equipment is widely used, these sensors because of restrictions on does not provide sufficient functional knowledge of hardware. As the external environment, particularly with a grade of this sensor is scanned, the thin barriers if such situations will emerge [3]. In addition to this, what is the detected barriers and to provide detailed information about the classification, it is impossible to make

There is a continuing need to improve safety at Railway Level Crossings particularly those that do not have gates and lights regulating traffic flow. A number of Intelligent Transport System interventions have been proposed to improve drivers' awareness and reduce errors in detecting and responding appropriately at level crossings. However, as with other technologies, successful implementation and ultimately effectiveness rests with the acceptance of the technology by the end user.

The parameter considered will be categorized according to various factors. There are engineering infrastructure, level crossing surrounding environment and human factors as in Fig. 1.

Schematic representation and dimensions of the proposed prototype train system is described in details in Fig.2.

In this section, design methodology development in assessing the level of risk at RLC locations is shown in Fig. 3. The purpose of the design is to give good background on real time systems. There are three phases involved in this modeling process. Firstly, model creation phase requires an understanding on the RLC operation, current practice and tools available for analysis.

The case study of this research will cover active types of RLC in Turkey. Therefore, the understanding of the overall concept of active types of RLC operations is needed. The basis of understanding of RLC operation obtained from the Turkish Standard. All instruments of the prototype system is drawn and outlined according to category as illustrated in Fig. 4. There are few studies using SPN and its extension dealing with safety study at RLC. By referring to the research gap, an improvement will be made in terms of the parameter consideration and categorization. The engineering infrastructure, level crossing surrounding environment and human factors will be the factors considered. The prototype of the rail way and intelligent crossing system is shown in Fig. 5.

The system was tested with different working speeds for analyzing vibration conditions of railway. However, the purpose of this analyze is to predict opening and closing time of bars of railway crossing system.

The proposed railway crossing system was tested with different operating speeds and points for performance and vibration analysis. For each test, four acceleration sensors having identical technical characteristics were used to analyze the system. These sensors were firstly placed on the right side of the system taking the level crossing as the reference, and vibration data were obtained for three different speeds (low, average high). Then the acceleration sensors were placed on the left side of the system and, again, vibration data were obtained for three different speeds (see Fig. 6). From the figure, the placed sensors were indicated for position of railway. In both test groups, the acceleration sensors were placed on exactly opposing positions, just next to the level crossing, on the bend start, on the straight line and on the bend end. The results of these approaches were outlined in the Figs. 7-10 for the case of right side of the system. The results indicates results of 4 sensors measurements. As can be seen from figure there is accelerations between 15 and 20 seconds.

On the right system, unlike in the left, the distance on the point where the rails unite where the second accelerometer was placed is slightly more. Therefore, higher vibration peak point values were obtained compared with the left system (see Fig. 11). A switch line exists just next to where the third accelerometer is located in the right system. The results of these approaches were outlined in the Figs. 12-14 for the case of left side of the system. The results indicates results of 4 sensors measurements. As can also be seen from figure there is accelerations between 15 and 20 seconds This resulted in higher, compared with the left system, peak values in all speeds. Besides, in all tests, the peak point values obtained from all vibration sensors increased in parallel with the increase of vibration frequency as velocity increased.

A complete tour time of the train for low, average and high speeds is 32.5, 18 and 13 seconds, respectively. The opening and closing times of the level crossing varies accordingly.

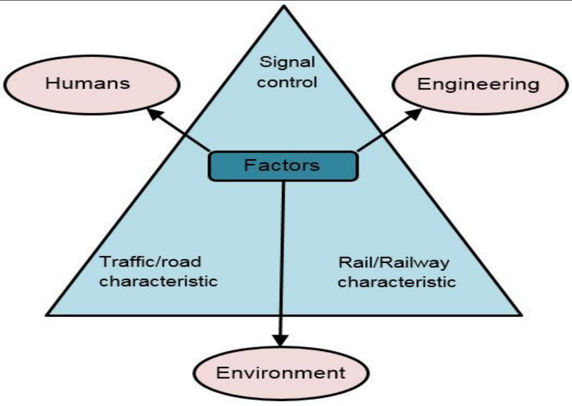


Fig. 1. The effects of railway crossing system. [8]

Fig. 5. Proposed experimental railway and crossing set-up prototype with instruments

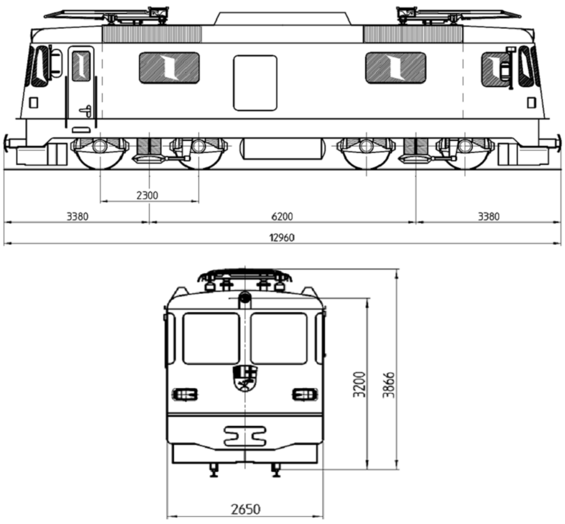


Fig. 2. Real time dimensions of Machine system

Fig. 6. View measuring position of vibration sensors on the right side of the system

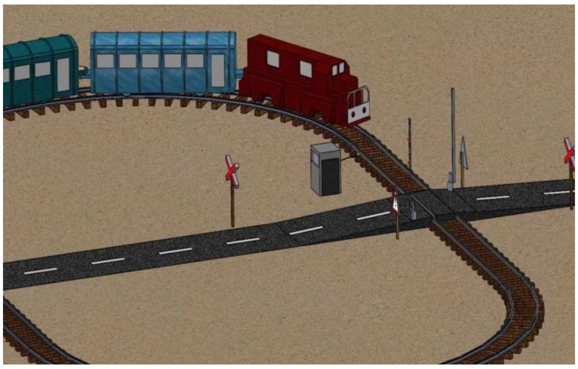


Fig. 3. Designed proposed railway level crossing system.

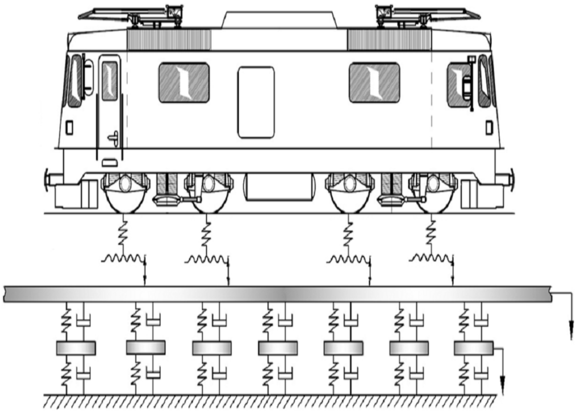


Figure 7. Dynamics model of protype train system

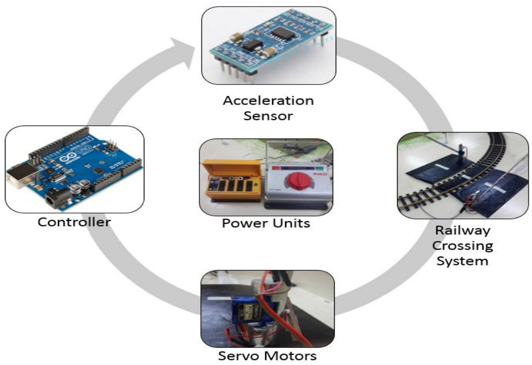
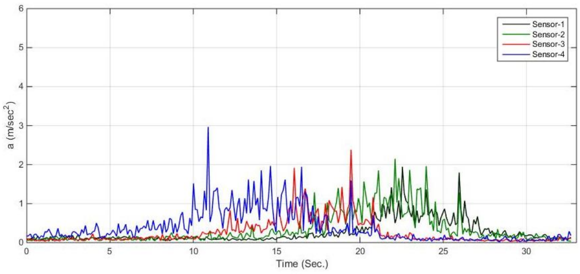


Fig. 4. Schematic representation experimental approach analysis of proposed railway level crossing system



Dd

Fig. 8. Acceleration variation prototype of train system with 0,35 m/sec speed for right side

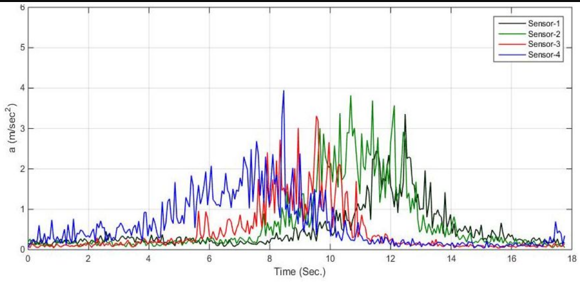


Fig. 9. Acceleration variation prototype of train system with 0,65 m/sec speed for right side

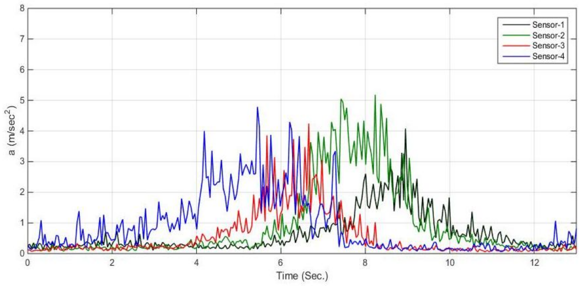


Fig. 10. Acceleration variation prototype of train system with 0,95 m/sec speed for right side

Fig. 11. View measuring position of vibration sensors on the left side of the system

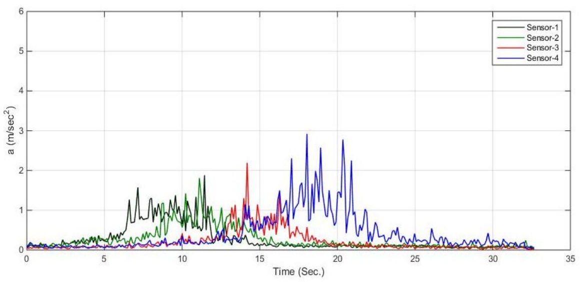


Fig. 12. Acceleration variation train system with 0,35 m/sec speed for left side

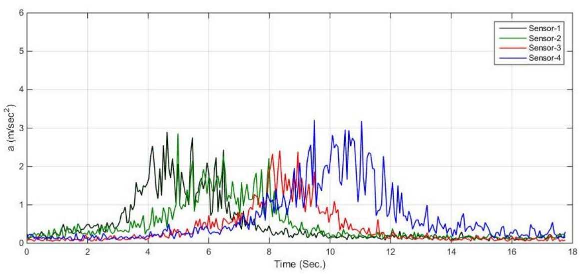


Fig. 13. Acceleration variation train system with 0,65 m/sec speed for left side

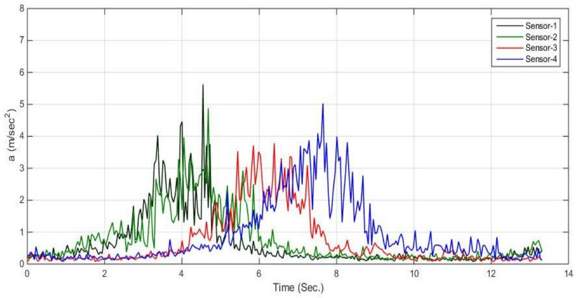


Fig. 14. Acceleration variation train system with 0,95 m/sec speed for left side

CONCLUSIONS AND DISCUSSION

In the world, in spite of advanced technology, railway level crossings (RLC) accidents and fatalities are still continuing and become the great concern in railway industries and passengers in especially when it involved fatalities. This paper has described an experimental prototype research framework in developing RLC safety systems specifically for Turkey's as a case study. The proposed research design in developing a risk index is outlined. The parameter considered will be justified during the model development stages. Since RLC safety systems is complex, the used of intelligent control approach in reliability safety engineering studies will be applied in order to have better understanding on the behavior of the systems. The components such as engineering infrastructure, level crossing surrounding environment and human factors considered in the prototype model can help in selecting a sound alternative for selected location for further improvements.

On the other hand, it is not easy and cheap to make real time experimental set-up for such systems, because of very high project budget .

The main motivation and purpose of this experimental work is to identify low-risk, low-cost, accidents and fatalities railway level crossings solutions.

In principle, there are a number of possible strategies for reducing crashes at railway level crossings. These include: Improving the conspicuity of the train, in order to increase the probability that the driver of the road vehicle will detect the train. Providing active control at the crossing, eliminating the need for a driver to make a decision. Providing some form of direct communication between the train and the road vehicle which would warn the driver of the approaching train. Improving crossing signing, markings and other forms of passive warning. Education, training or enforcement programs aimed at road vehicle drivers. Improving sight distance or reducing the speed of trains and/or road vehicles. Closing the crossing.

The future stage of this investigation will use a rail-way traffic simulation approach with behavioral models developed for evaluating the short-listed systems. The tools developed in this study will provide rail authorities and researchers with the means to evaluate railway level crossings protection systems to improve safety at level crossings.

ACKNOWLEDGMENT

Authors would like to express their deepest appreciation to Erciyes University, which provided us the opportunity to support **FCD-2014-5163** coded this project. Authors would also like to thank Rail-way Company in Turkey providing them broad information, and documents about conditions and infrastructure of rail-way system in Turkey.

REFERENCES

[1] P. Chartier, "Level Crossing Safety in Countries of the Asia-Pacific Region," 22 ASEAN Railway General Managers' Conference. Yangon, Myanmar, 2000.

[2] V. Gitelman and A. S. Hakkert, "The Evaluation of Road-Rail Crossing Safety with Limited Accident Statistics," Accident Analysis & Prevention, vol.29, pp.171-179, 1997.

[3] J. K. Caird, J. I. Creaser, C. J. Edwards and R. E. Dewar, "A Human Factors Analysis of Highway-Railway Grade Crossing Accidents in Canada,". Fourth Workshop on Highway-Railway Grade Crossing Research Montreal, Quebec, Transportation Development Centre, Publication Distribution Services, 2002.

[4] D. W. Harwood, W. D. Glauz and J. M. Mason, "Stopping Sight Distance Design for Large Trucks," Transportation Research Record, 1208, 1989

[5] F. Saccomanno, L. Fu, C. Ren and L. Miranda, "Identifying Highway-Rail Grade Crossing Black Spots in Canada," Phase 1 TP 14168E. Montreal Quebec, Transportation Development Centre, Transport Canada, 2003.

[6] J. Carson and F. Mannering, "The Effect of Ice Warning Signs on Ice-Accident Frequencies and Severities," Accident Analysis & Prevention, vol.33, pp.99-109, 2001.

[7] E. C. Wigglesworth, "Human Factors in Level Crossing Accidents" Accident Analysis & Prevention, vol.10, pp. 229-240, 1978.

[8] I. S. Zaharah, "The development of railway level crossing safety assessment model: a research framework," 29th Conference of Australian Institutes of Transport Research (CAITR) Adelaide, pp. 1-11, 5th - 7th December 2007.

[9] S.S. Mostafa, M. M. Hossian, K. J. Reza, G. M. Rashid, “A Radio Based Intellıgent Railway Grade Crossing System to Avoid Collision” International Journal of Computer Science Issues, Vol.7, pp.139-143, 2010

[10] J. Banuchandar, V. Kaliraj, P. Balasubramanian, S. Deepa, N. Thamilarasi, “Automated Unmanned Railway Level Crossing System”, International Journal of Modern Engineering Research, Vol.2, pp.458-463, 2012

[11] S. Sezer, A. E. Atalay, “Dynamic Modelling and Fuzzy Logic Control of Vibrations of a Railway Vehicle for Different Track Irregularities”, Simulation Modelling Practice and Theory, Vol.19, pp.1873-1894, 2011

[12] C. Cole, “Handbook of Railway Vehicle Dynamics” , Taylor & Francis Group, 6000 Broken Sound Parkway NW, Suite 300, 2006.

★★★

Design and Experimental Noise Analysis Intelligent Railway Level Crossing System

Şahin Yıldırım, and Şükru Su
Erciyes University, Engineering Faculty,
Mechatronic Engineering Department
Kayseri-Turkey
sahiny@erciyes.edu.tr

Çağlar Sevim and Menderes Kalkat
Nigde University, Engineering Faculty
Mechanical Engineering Department
Niğde-Turkey

***Abstract*--- Due to increased population in the world, it is necessary to prefer railway travelling for passengers. Nowadays, rail-way crossing system are very important parts of railway systems. Uncontrolled railway crossing; it becomes very dangerous for car drivers; because of railway conditions and fast passing. This paper presents an investigation on intelligent railway and crossing design and analysis with intelligent sensor and control technology. Firstly, the prototype were designed with all instruments and conditions. Secondly; the prototype of system was set-up as designed conditions. The train system was tested with different working speeds. However, the system's vibrations were analyzed for different working speeds. On the other hand the closing and opening times were changed with different speeds of railway systems. A research framework on the development of Railway Level Crossing safety assessment model. Even though Railway Level Crossing accidents can be considered as a rare event, the impact is often severe. Since Railway Level Crossing safety systems are complex and dealing with at least two transport modes. The components of basic concept of safety engineering; engineering infrastructure, level crossing surrounding environment and human factors will be also considered in the model.**

***Key words*: rail-way level crossing, train system, vibration analysis.**

I.INTRODUCTION

There are some research results that have been investigated by other researchers. Railway level crossing (RLC) accidents is one of the major contributing factors of railway related fatality problems in many countries. In Turkey, safety issues at RLC are very serious relative to those of developing countries. However, RLC accidents have continuously become a problem in railway industries in especially when it involved fatalities. RLC is considered as a unique intersection. The systems are complex and dealing with at least two mode of transport. Therefore collision between motor vehicles and trains is likely to happen at RLC and cause catastrophic consequences [1], [2].

Safety and the operational problems at RLC can be further classified into highway and railway. The highway component comprises drivers, pedestrians, vehicles and roadway segments, whereas the train component is classified into train and track at crossing locations. The functions and characteristics of the two components and their corresponding elements represent the risk at RLC locations. Various studies have been conducted in many countries, based on a range of issues associated with safety level at RLC. Accident at RLC may be caused by a single factor or by the combination of many other factors. There is a growing realization of the need to consider contributory factors involved in accidents at RLC. Caird [3] has recommended that emphasis need to be focused on the multiple contributors to accident at RLC rather than looking at a single factor only. As in basic safety engineering studies; there are at least three basic contributing factors need to be considered. There are engineering infrastructure, level crossing surrounding environment and human factors. To address these issues, Caird discussed the angle and visibility aspects at RLC while other researchers studied factors associated with RLC due to familiarity, misjudgment and distraction. Additionally, the works of Caird [3], and Harwood [4] also argued the technical contributing factors related to the configuration and design of RLCs.

Various accident prediction equations and risk indexes were developed in order to cater for the problems at RLC. Study conducted by Saccomanno [5] revealed two basic perspectives of model developed in the United States during 1950 to 1970. These were absolute model and the relative risk model. The absolute models denote the expected number of collision at a given crossing for a given period of time as developed and the US Department of Transportation (USDOT). Meanwhile the hazard index yield the relative risk of one crossing compared to another. Several relative risk indices have been developed; the Mississippi Formula (1970), the New Hampshire Formula (1971), the Ohio Method (1959), the Wisconsin Method(1974), Contra Costa Country Method (1969), the Oregon Method (1956), The North Dakota Rating System(1965), The Idaho Formula(1964), the Utah Formula (1971) and the City of Detroit Formula (1971). The US DOT model was generally recognized as the industry standard. The analysis methods used range from Multiple Linear Regressions to techniques including special statistical distributions such as the Poisson and Negative Binomial distribution [6]. However, past data is vital for analysis purposes. The lack of data in some countries is a drawback of traditional approaches and leads to leave the problem of RLC untreated [7].

II. THE PROPOSED RESEARCH DESIGN AND ANALYSIS

There is a continuing need to improve safety at Railway Level Crossings particularly those that do not have gates and lights regulating traffic flow. A number of Intelligent Transport System interventions have been proposed to improve drivers' awareness and reduce errors in detecting and responding appropriately at level crossings. However, as with other technologies, successful implementation and ultimately effectiveness rests with the acceptance of the technology by the end user.

The parameter considered will be categorized according to various factors. There are engineering infrastructure, level crossing surrounding environment and human factors as in Fig. 1.

In this section, design methodology development in assessing the level of risk at RLC locations is shown in Fig. 2. The purpose of the design is to give good background on real time systems. There are three phases involved in this modeling process. Firstly, model creation phase requires an understanding on the RLC operation, current practice and tools available for analysis.

The case study of this research will cover active types of RLC in Turkey. Therefore, the understanding of the overall concept of active types of RLC operations is needed. The basis of understanding of RLC operation obtained from the Turkish Standard. All instruments of the prototype system is drawn and outlined according to category as illustrated in Fig. 3. There are few studies using SPN and its extension dealing with safety study at RLC. By referring to the research gap, an improvement will be made in terms of the parameter consideration and categorization. The engineering infrastructure, level crossing surrounding environment and human factors will be the factors considered. The prototype of the rail way and intelligent crossing system is shown in Fig. 4.

The system was tested with different working speeds for analyzing vibration conditions of railway. However, the purpose of this analyze is to predict opening and closing time of bars of railway crossing system.

Figure 5 describes acceleration variation of railway with low speeds (2 km/h). As can be seen from figure, passing time of train is 10 seconds with peak overshoot. The cycle time of the train system is 22.5 seconds. Figure 6 is outlined acceleration variation of railway system with mid-low speeds. As can be seen from figure, passing time of train is 10 seconds with peak overshoot again. The cycle time of the train system is 14.2 seconds for speed of 3 km/h. Figure 7 shows acceleration variation of railway system with maximum speed. As can be seen from figure, passing time of train is 10 seconds with low peak overshoot time. The cycle time of the train system is 11.3 seconds for speed of 4 km/h. From these approaches, the closing and opening time rail-way crossing bars has sequence with speeds of train system.

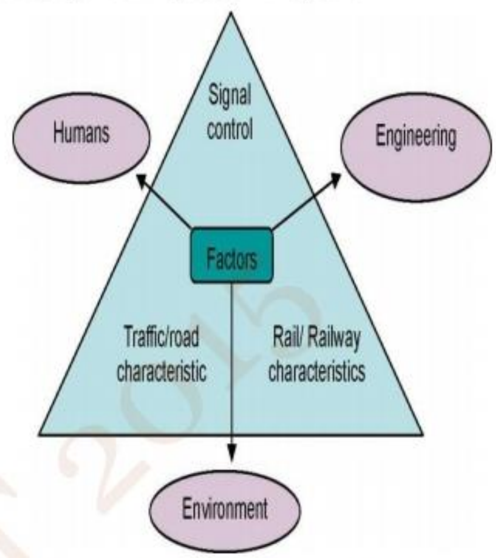


Fig. 1. The effects of railway crossing system. [8]

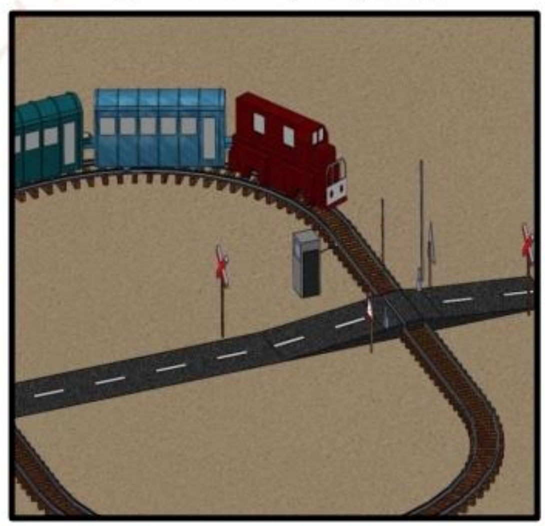


Fig. 2. Designed railway level crossing system.

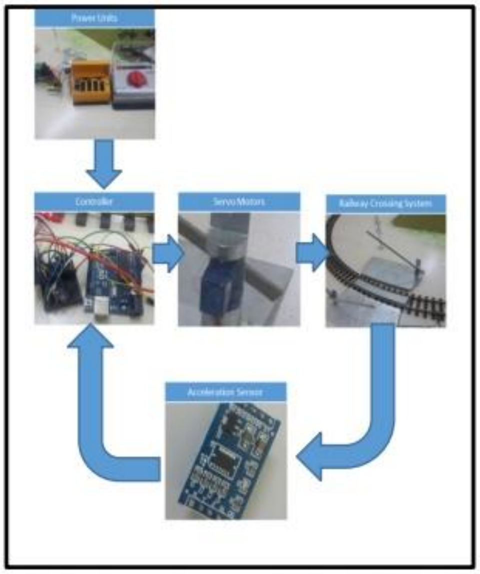


Fig. 3. Schematic representation experimental approach of railway level crossing system.

Fig. 4. View of experimental set-up prototype

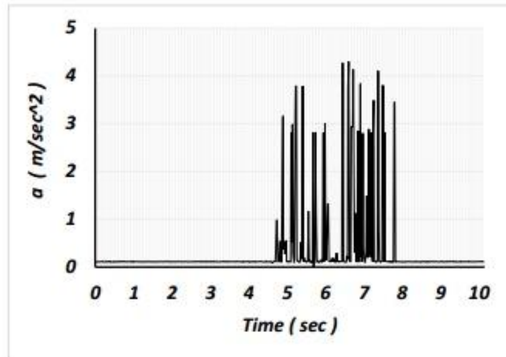


Fig. 5. Acceleration variation train system with 2 km/h speed

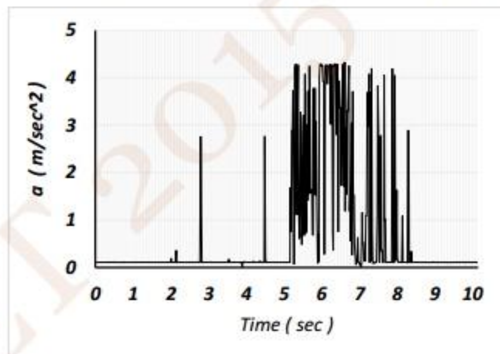


Fig. 6. Acceleration variation train system with 3 km/h speed

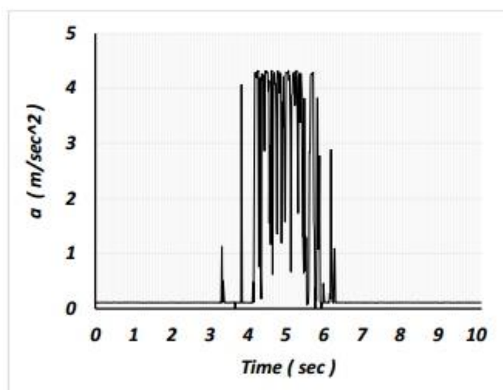


Fig. 7. Acceleration variation train system with 4 km/h speed

III. Conclusions And Discussion

In Turkey, railway level crossings (RLC) accidents are still continuing and become the great concern in railway industries and passengers in especially when it involved fatalities. This paper describes an experimental prototype research framework in developing RLC safety systems specifically for Turkey's as a case study. The proposed research design in developing a risk index is outlined. The parameter considered will be justified during the model development stages. Since RLC safety systems is complex, the used of intelligent control approach in reliability safety engineering studies will be applied in order to have better understanding on the behavior of the systems. The components such as engineering infrastructure, level crossing surrounding environment and human factors considered in the prototype model can help in selecting a sound alternative for selected location for further improvements.

On the other hand, it is not easy and cheap to make real time experimental set-up for such systems. The main motivation and purpose of this experimental work is to identify low-risk, low-cost, accidents and fatalities railway level crossings solutions.

In principle, there are a number of possible strategies for reducing crashes at railway level crossings. These include: Improving the conspicuity of the train, in order to increase the probability that the driver of the road vehicle will detect the train. Providing active control at the crossing, eliminating the need for a driver to make a decision. Providing some form of direct communication between the train and the road vehicle which would warn the driver of the approaching train. Improving crossing signing, markings and other forms of passive warning. Education, training or enforcement programs aimed at road vehicle drivers. Improving sight distance or reducing the speed of trains and/or road vehicles. Closing the crossing.

The future stage of this investigation will use a rail-way traffic simulation approach with behavioral models developed for evaluating the short-listed systems. The tools developed in this study will provide rail authorities and researchers with the means to evaluate railway level crossings protection systems to improve safety at level crossings.

IV. Acknowledgment

We would like to express our deepest appreciation to Erciyes University, which provided us the opportunity to support **FCD-2014-5163** coded this project. We would also like to thank Rail-way company in Turkey providing us conditions and infrastructure of rail-way system in Turkey.

References

[1] P. Chartier, "Level Crossing Safety in Countries of the Asia-Pacific Region," 22 ASEAN Railway General Managers' Conference. Yangon, Myanmar, 2000.

[2] V. Gitelman and A. S. Hakkert, "The Evaluation of Road- Rail Crossing Safety with Limited Accident Statistics," Accident Analysis & Prevention, vol.29, pp.171-179, 1997.

[3] J. K. Caird, J. I. Creaser, C. J. Edwards and R. E. Dewar, "A Human Factors Analysis of Highway-Railway Grade Crossing Accidents in Canada,". Fourth Workshop on Highway-Railway Grade Crossing Research Montreal, Quebec, Transportation Development Centre, Publication Distribution Services, 2002.

[4] D. W. Harwood, W. D. Glauz and J. M. Mason, "Stopping Sight Distance Design for Large Trucks," Transportation Research Record, 1208, 1989

[5] F. Saccomanno, L. Fu, C. Ren and L. Miranda, "Identifying Highway-Rail Grade Crossing Black Spots in Canada," Phase 1 TP 14168E. Montreal Quebec, Transportation Development Centre, Transport Canada, 2003.

[6] J. Carson and F. Mannering, "The Effect of Ice Warning Signs on Ice-Accident Frequencies and Severities," Accident Analysis & Prevention, vol.33, pp.99-109, 2001.

[7] E. C. Wigglesworth, "Human Factors in Level Crossing Accidents" Accident Analysis & Prevention, vol.10, pp. 229-240, 1978.

[8] I. S. Zaharah, "The development of railway level crossing safety assessment model: a research framework," 29th Conference of Australian Institutes of Transport Research (CAITR) Adelaide, pp. 1-11, 5th – 7th December 2007

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 5, Special Issue 4, March 2015)

Analysis Experimental Intelligent Railway Level Crossing System

Sahin YILDIRIM[1], Caglar SEVIM[2], Sukru SU[3], Menderes KALKAT[4]
[1,3]*Erciyes University, Engineering Faculty, Mechatronic Engineering Department*
[2,4]*Nigde University, Engineering Faculty, Mechanical Engineering Department*
sahiny@erciyes.edu.tr, caglar.sevim@nigde.edu.tr, su@erciyes.edu.tr, mkalkat@nigde.edu.tr

Abstract*- In recent years, in spite of increased population in the world, it is necessary to prefer railway travelling for passengers. Nowadays, rail-way crossing system are very important parts of railway systems. Uncontrolled railway crossing; it becomes very dangerous for car drivers; because of railway conditions and fast passing. This paper presents an investigation on intelligent railway and crossing design and analysis with intelligent sensor and control technology. Firstly, the prototype were designed with all instruments and conditions. Secondly; the prototype of system was set-up as designed conditions. The train system was tested with different working speeds. However, the system's vibrations were analyzed for different working speeds. On the other hand the closing and opening times were changed with different speeds of railway systems. A research framework on the development of Railway Level Crossing safety assessment model. Even though Railway Level Crossing accidents can be considered as a rare event, the impact is often severe. Since Railway Level Crossing safety systems are complex and dealing with at least two transport modes. The components of basic concept of safety engineering; engineering infrastructure, level crossing surrounding environment and human factors will be also considered in the model.

***Keywords*-- rail-way level crossing, train system, vibration analysis**

I. INTRODUCTION

There are some research results that have been investigated by other researchers. Railway level crossing (RLC) accidents is one of the major contributing factors of railway related fatality problems in many countries. In Turkey, safety issues at RLC are very serious relative to those of developing countries. However, RLC accidents have continuously become a problem in railway industries in especially when it involved fatalities. RLC is considered as a unique intersection. The systems are complex and dealing with at least two mode of transport. Therefore collision between motor vehicles and trains is likely to happen at RLC and cause catastrophic consequences [1], [2].

Safety and the operational problems at RLC can be further classified into highway and railway.

The highway component comprises drivers, pedestrians, vehicles and roadway segments, whereas the train component is classified into train and track at crossing locations. The functions and characteristics of the two components and their corresponding elements represent the risk at RLC locations. Various studies have been conducted in many countries, based on a range of issues associated with safety level at RLC. Accident at RLC may be caused by a single factor or by the combination of many other factors. There is a growing realization of the need to consider contributory factors involved in accidents at RLC. Caird [3] has recommended that emphasis need to be focused on the multiple contributors to accident at RLC rather than looking at a single factor only. As in basic safety engineering studies; there are at least three basic contributing factors need to be considered. There are engineering infrastructure, level crossing surrounding environment and human factors. To address these issues, Caird discussed the angle and visibility aspects at RLC while other researchers studied factors associated with RLC due to familiarity, misjudgment and distraction. Additionally, the works of Caird [3], and Harwood [4] also argued the technical contributing factors related to the configuration and design of RLCs.

Various accident prediction equations and risk indexes were developed in order to cater for the problems at RLC. Study conducted by Saccomanno [5] revealed two basic perspectives of model developed in the United States during 1950 to 1970. These were absolute model and the relative risk model. The absolute models denote the expected number of collision at a given crossing for a given period of time as developed and the US Department of Transportation (USDOT). Meanwhile the hazard index yield the relative risk of one crossing compared to another. Several relative risk indices have been developed; the Mississippi Formula (1970), the New Hampshire Formula (1971), the Ohio Method (1959), the Wisconsin Method(1974), Contra Costa Country Method (1969), the Oregon Method (1956), The North Dakota Rating System(1965), The Idaho Formula(1964), the Utah Formula (1971) and the City of Detroit Formula (1971).

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 5, Special Issue 4, March 2015)

The US DOT model was generally recognized as the industry standard. The analysis methods used range from Multiple Linear Regressions to techniques including special statistical distributions such as the Poisson and Negative Binomial distribution [6]. However, past data is vital for analysis purposes. The lack of data in some countries is a drawback of traditional approaches and leads to leave the problem of RLC untreated [7].

II. The Proposed Experimental Analysis

There is a continuing need to improve safety at Railway Level Crossings particularly those that do not have gates and lights regulating traffic flow. A number of Intelligent Transport System interventions have been proposed to improve drivers' awareness and reduce errors in detecting and responding appropriately at level crossings. However, as with other technologies, successful implementation and ultimately effectiveness rests with the acceptance of the technology by the end user.

The parameter considered will be categorized according to various factors. There are engineering infrastructure, level crossing surrounding environment and human factors as in Fig. 1.

In this section, design methodology development in assessing the level of risk at RLC locations is shown in Fig. 2. The purpose of the design is to give good background on real time systems. There are three phases involved in this modeling process. Firstly, model creation phase requires an understanding on the RLC operation, current practice and tools available for analysis.

The case study of this research will cover active types of RLC in Turkey. Therefore, the understanding of the overall concept of active types of RLC operations is needed. The basis of understanding of RLC operation obtained from the Turkish Standard. All instruments of the prototype system is drawn and outlined according to category as illustrated in Fig. 3. There are few studies using SPN and its extension dealing with safety study at RLC. By referring to the research gap, an improvement will be made in terms of the parameter consideration and categorization. The engineering infrastructure, level crossing surrounding environment and human factors will be the factors considered. The prototype of the rail way and intelligent crossing system is shown in Fig. 4.

The system was tested with different working speeds for analyzing vibration conditions of railway. However, the purpose of this analyze is to predict opening and closing time of bars of railway crossing system.

The proposed railway crossing system was tested with different operating speeds and points for performance and vibration analysis. For each test, four acceleration sensors having identical technical characteristics were used to analyze the system.

These sensors were firstly placed on the right side of the system taking the level crossing as the reference, and vibration data were obtained for three different speeds (low, average high). Then the acceleration sensors were placed on the left side of the system and, again, vibration data were obtained for three different speeds (see Figure 5). In both test groups, the acceleration sensors were placed on exactly opposing positions, just next to the level crossing, on the bend start, on the straight line and on the bend end. The results of these approaches were outlined in the Figures 6-8 for the case of right side of the system. The results indicates results of 4 sensors measurements. As can be seen from figure there is accelerations between 15 and 20 seconds.

On the right system, unlike in the left, the distance on the point where the rails unite where the second accelerometer was placed is slightly more. Therefore, higher vibration peak point values were obtained compared with the left system (see Figure 9). A switch line exists just next to where the third accelerometer is located in the right system. The results of these approaches were outlined in the Figures 10-12 for the case of left side of the system. The results indicates results of 4 sensors measurements. As can also be seen from figure there is accelerations between 15 and 20 seconds This resulted in higher, compared with the left system, peak values in all speeds. Besides, in all tests, the peak point values obtained from all vibration sensors increased in parallel with the increase of vibration frequency as velocity increased.

A complete tour time of the train for low, average and high speeds is 32.5, 18 and 13 seconds, respectively. The opening and closing times of the level crossing varies accordingly.

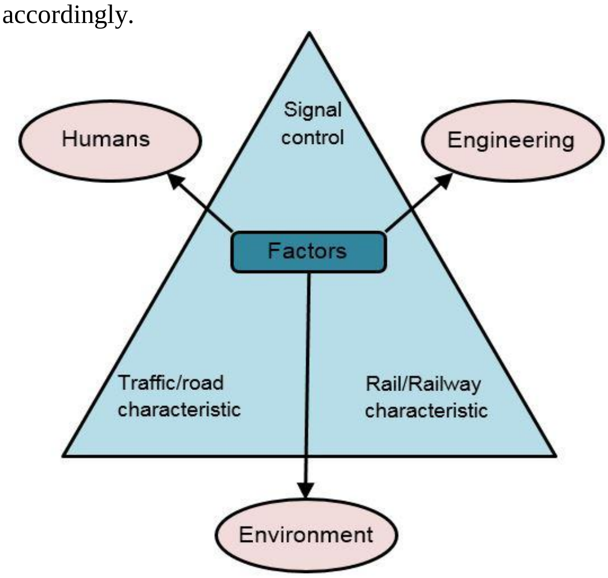


Fig. 1. The effects of railway crossing system. [8]

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 5, Special Issue 4, March 2015)

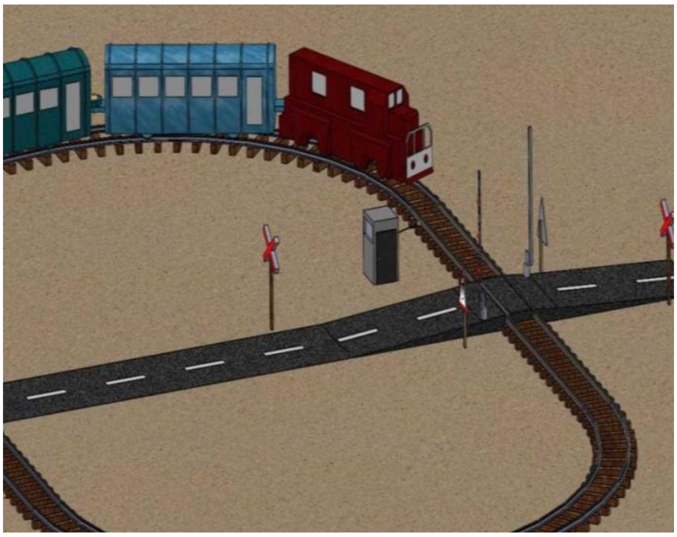


Fig. 2. Designed railway level crossing system.

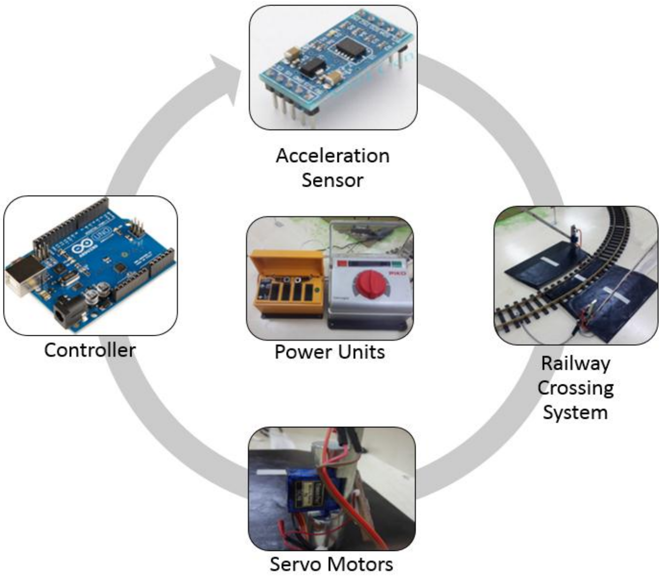


Fig. 3. Schematic representation experimental approach of railway level crossing system

Fig. 4. View of experimental set-up prototype

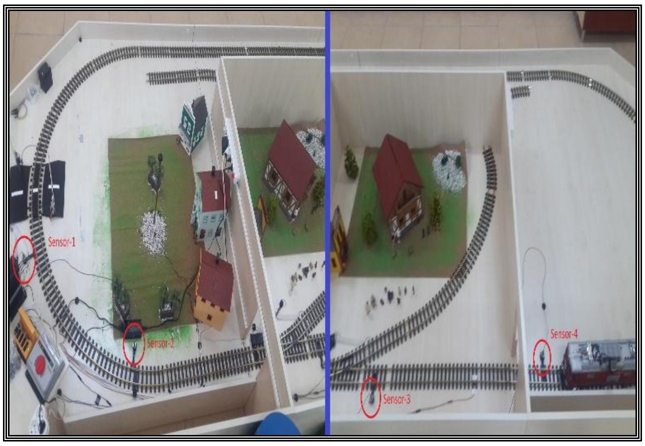


Fig. 5. View of vibration sensors on the right side of the system

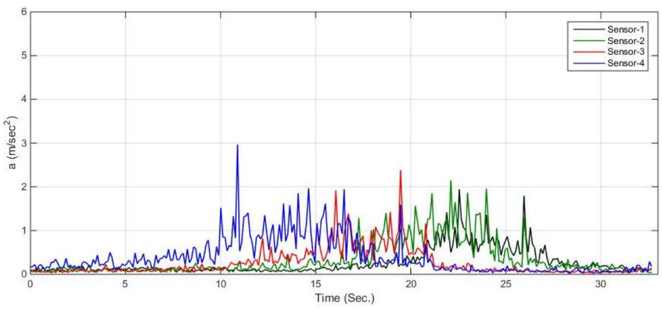


Fig. 6. Acceleration variation train system with 0,35 m/sec speed for right side

IJETAE
EXPLORING RESEARCH AND INNOVATIONS

International Journal of Emerging Technology and Advanced Engineering
Website: www.ijetae.com (ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 5, Special Issue 4, March 2015)

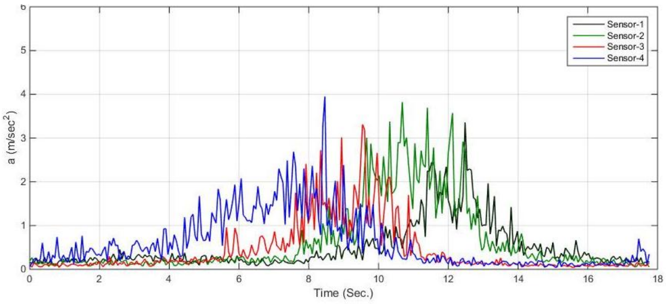


Fig. 7. Acceleration variation train system with 0,65 m/sec speed for right side

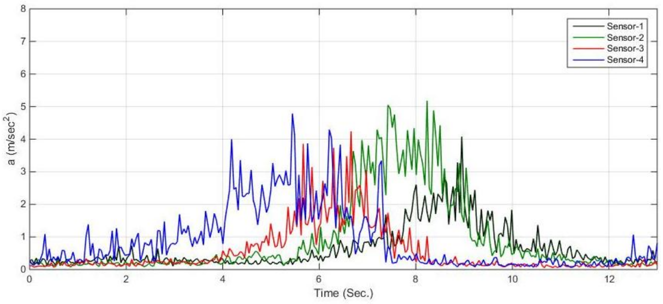


Fig. 8. Acceleration variation train system with 0,95 m/sec speed for right side

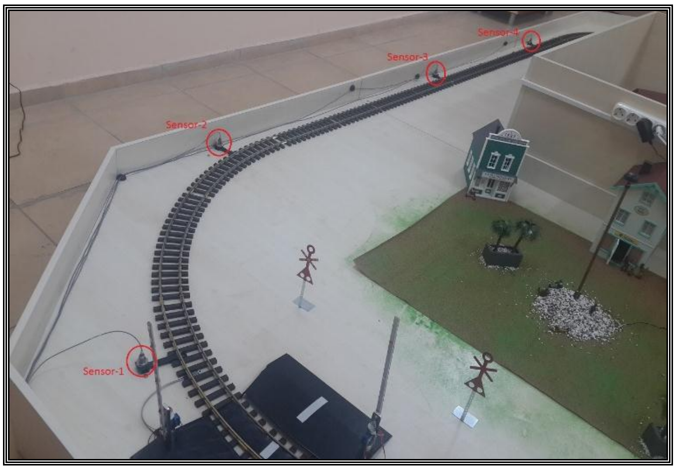


Fig. 9. View of vibration sensors on the left side of the system

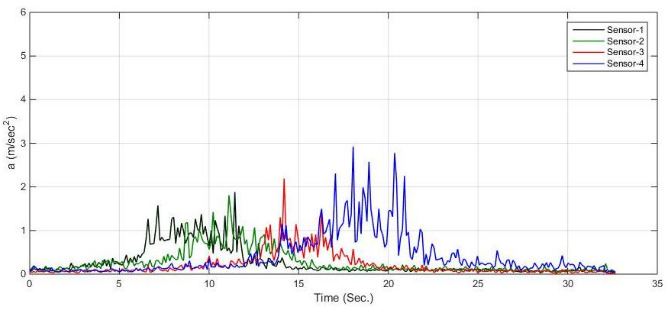


Fig. 10. Acceleration variation train system with 0,35 m/sec speed for left side

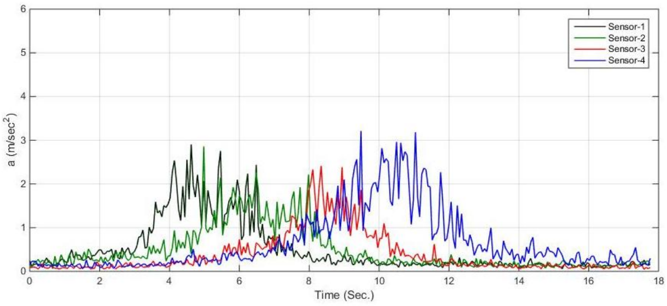


Fig. 11. Acceleration variation train system with 0,65 m/sec speed for left side

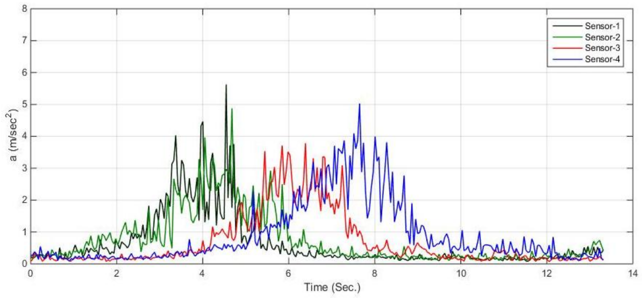


Fig. 12. Acceleration variation train system with 0,95 m/sec speed for left side

III. CONCLUSIONS AND DISCUSSION

In the world, in spite of advanced technology, railway level crossings (RLC) accidents and fatalities are still continuing and become the great concern in railway industries and passengers in especially when it involved fatalities. This paper describes an experimental prototype research framework in developing RLC safety systems specifically for Turkey's as a case study. The proposed research design in developing a risk index is outlined. The parameter considered will be justified during the model development stages. Since RLC safety systems is complex, the used of intelligent control approach in reliability safety engineering studies will be applied in order to have better understanding on the behavior of the systems. The components such as engineering infrastructure, level crossing surrounding environment and human factors considered in the prototype model can help in selecting a sound alternative for selected location for further improvements.

On the other hand, it is not easy and cheap to make real time experimental set-up for such systems.

The main motivation and purpose of this experimental work is to identify low-risk, low-cost, accidents and fatalities railway level crossings solutions.

In principle, there are a number of possible strategies for reducing crashes at railway level crossings. These include: Improving the conspicuity of the train, in order to increase the probability that the driver of the road vehicle will detect the train. Providing active control at the crossing, eliminating the need for a driver to make a decision. Providing some form of direct communication between the train and the road vehicle which would warn the driver of the approaching train. Improving crossing signing, markings and other forms of passive warning. Education, training or enforcement programs aimed at road vehicle drivers. Improving sight distance or reducing the speed of trains and/or road vehicles. Closing the crossing.

The future stage of this investigation will use a rail-way traffic simulation approach with behavioral models developed for evaluating the short-listed systems. The tools developed in this study will provide rail authorities and researchers with the means to evaluate railway level crossings protection systems to improve safety at level crossings.

Acknowledgment

We would like to express our deepest appreciation to Erciyes University, which provided us the opportunity to support FCD-2014-5163 coded this project. We would also like to thank Rail-way Company in Turkey providing us conditions and infrastructure of rail-way system in Turkey.

REFERENCES

[1] P. Chartier, "Level Crossing Safety in Countries of the Asia-Pacific Region," 22 ASEAN Railway General Managers' Conference. Yangon, Myanmar, 2000.

[2] V. Gitelman and A. S. Hakkert, "The Evaluation of Road- Rail Crossing Safety with Limited Accident Statistics," Accident Analysis & Prevention, vol.29, pp.171-179, 1997.

[3] J. K. Caird, J. I. Creaser, C. J. Edwards and R. E. Dewar, "A Human Factors Analysis of Highway-Railway Grade Crossing Accidents in Canada,". Fourth Workshop on Highway-Railway Grade Crossing Research Montreal, Quebec, Transportation Development Centre, Publication Distribution Services, 2002.

[4] D. W. Harwood, W. D. Glauz and J. M. Mason, "Stopping Sight Distance Design for Large Trucks," Transportation Research Record, 1208, 1989

[5] F. Saccomanno, L. Fu, C. Ren and L. Miranda, "Identifying Highway-Rail Grade Crossing Black Spots in Canada," Phase 1 TP 14168E. Montreal Quebec, Transportation Development Centre, Transport Canada, 2003.

[6] J. Carson and F. Mannering, "The Effect of Ice Warning Signs on Ice-Accident Frequencies and Severities," Accident Analysis & Prevention, vol.33, pp.99-109, 2001.

[7] E. C. Wigglesworth, "Human Factors in Level Crossing Accidents" Accident Analysis & Prevention, vol.10, pp. 229-240, 1978.

[8] I. S. Zaharah, "The development of railway level crossing safety assessment model: a research framework," 29th Conference of Australian Institutes of Transport Research (CAITR) Adelaide, pp. 1-11, 5th - 7th December 2007

[9] S. S. Mostafa, M. M. Hossian, K. J. Reza, G. M. Rashid, "A Radio Based Intellıgent Railway Grade Crossing System to Avoid Collision" International Journal of Computer Science Issues, Vol.7, pp.139-143, 2010

[10] J. Banuchandar, V. Kaliraj, P. Balasubramanian, S. Deepa, N. Thamilarasi, "Automated Unmanned Railway Level Crossing System", International Journal of Modern Engineerin Research, Vol.2, pp.458-463, 2012

[11] S. Sezer, A. E. Atalay, "Dynamic Modelling and Fuzzy Logic Control of Vibrations of a Railway Vehicle for Different Track Irregularities", Simulation Modelling Practice and Theory, Vol.19, pp.1873-1894, 2011

[12] C. Cole, "Handbook of Railway Vehicle Dynamics" , Taylor & Francis Group, 6000 Broken Sound Parkway NW, Suite 300, 2006