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Highlights

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Multiple Perceptual Map Generation using MDSvarext

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Abstract- Perceptual mapping is widely spread to assess perception in different areas, like marketing, political and social sciences, psychology and others. One opportunity for development is to add statistical inference on final configuration in order to consider inherent differences of a group of evaluators. The main objective is to produce multiple perceptual maps from focal panel and to incorporate the confidence regions of different evaluators into the visual representation using MDSvarext. The algorithm represents a joining of non metric multidimensional scaling, shape statistical tool, clustering techniques and non parametric estimation of variance-covariance matrix to generate a visual representation of object's perception and its confidence regions. An experiment to assess occupational risk perception has been run in order to demonstrate the method. The results showed that different perceptual maps are needed to encompass the variability of a focal group. The generated perceptual maps have different interpretations since the objects may be on opposite sides of the graph. The solution generated by MDsvarext was effective and statistical inference could be done. To explore the variability in focal groups is very important, and MDSvarext represents a path to be followed, since it was possible to visualize the differences that are statistical significant.

Keywords: clustering, multidimensional scaling, perception, perceptual map, statistical inference.

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Moacyr Machado Cardoso Junior [α] & Rodrigo Arnaldo Scarpel [σ]

Abstract- Perceptual mapping is widely spread to assess perception in different areas, like marketing, political and social sciences, psychology and others. One opportunity for development is to add statistical inference on final configuration in order to consider inherent differences of a group of evaluators. The main objective is to produce multiple perceptual maps from focal panel and to incorporate the confidence regions of different evaluators into the visual representation using MDSvarext. The algorithm represents a joining of non metric multidimensional scaling, shape statistical tool, clustering techniques and non parametric estimation of variance-covariance matrix to generate a visual representation of object's perception and its confidence regions. An experiment to assess occupational risk perception has been run in order to demonstrate the method. The results showed that different perceptual maps are needed to encompass the variability of a focal group. The generated perceptual maps have different interpretations since the objects may be on opposite sides of the graph. The solution generated by MDsvarext was effective and statistical inference could be done. To explore the variability in focal groups is very important, and MDSvarext represents a path to be followed, since it was possible to visualize the differences that are statistical significant.

Keywords: clustering, multidimensional scaling, perception, perceptual map, statistical inference.

I. Introduction

Perceptual maps are very useful and widely used among researchers of different areas, like marketing, behavioral sciences, econometrics, social and political sciences and risk perception (Moreira, 2006; Slovic, 2001; Vanlaar and Yannis, 2006; Cardoso-Junior and Scarpel, 2010).

Perceptual maps are obtained by multidimensional scaling (MDS), which is a statistical tool for dimensional reduction and visual representation of multivariate data.

Starting with a dissimilarity matrix MDS solves the problem of representing data in low dimensional space by making the inter-objects distance in low dimensional space as close as possible to the initial dissimilarity.

Statistical inference for MDS problems have been well debated in the past. Some researchers suggested that MDS should remain only as an exploratory technique or a visual representation of data. Nevertheless other researchers state that some efforts should be done to incorporate statistical inference in MDS models. (Cox and Cox, 2001)

One relevant question that arises refers to uncertainty of the final position of objects in MDS representation, especially if one is dealing with three-way MDS, which considers a group of different persons, assessing several objects on many attributes.

This paper presents the Multidimensional Scaling External Variability (MDSvarext) algorithm developed by Cardoso-Junior and Scarpel, (2012) that is an alternative to solve the problem of representing data originated in focal group studies which involves ordinal scales of judgment and inherent subjectivity.

The expected contribution of the work is to produce multiple three-way perceptual maps using visualization techniques of non metric multidimensional data, aided by a statistical shape tool. The methodological approach employed in this study was an exploratory research.

This paper aims to: i) obtain multiple perceptual maps using MDSvarext, ii) Present an experimental data set collected within a focal group and to represent it in a multiple perceptual map, iii) Split the focal group into homogeneous clusters, iii) to test statistical differences between intra-clusters objects.

This paper is organized as follows: the motivation and objectives for development of this work are presented in section 1. In Section 2 the theoretical framework of MDSvarext and three-way perceptual map generation are shown. In Section 3 we present the data and results obtained in this study. Section 4 presents the final considerations.

II. Theoretical Framework

a) MDSvarext algorithm

The MDSvarext algorithm is used to incorporate the variability inherent to group of evaluators into the perceptual map obtained via non metric multidimensional scaling (NMDS). The MDSvarext method has four phases: Dimension reduction, Configuration alignment and Clusterization, and Inferential analysis, as proposed by Cardoso-Junior and Scarpel, (2012).

In the first phase, based on individual dissimilarity matrices D, a SMACOF solution algorithm, proposed by De Leeuwn (1977) is applied in order to reduce dimensions.

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The SMACOF – Scaling by MAjorizing a COmplicated Function algorithm is used because we can guarantee a solution with monotone convergence of the Stress function, (Eq.1), proposed by Kruskal (1964).

$$\sigma_r(X) = w_{ij} \sum_{i<j}^{n} \left(d_{ij} - \delta_{ij}\right)^2 \quad (1)$$

where w_{ij} represents weights, n denotes the number of empirical objects, δ_{ij} is the dissimilarity between i and j, d_{ij} is the Euclidian distances between objects i and j in final space.

The main idea of SMACOF is to replace, iteratively, the original complicated function f(x) by an auxiliary function g(x;z). z is a known constant. The g function should comply with the following requisites, in order that g(x;z) be a majorizing function for f(x):

- auxiliary function g (x, z) should be easier to minimize than f (x);
- the original function must be less than or at most equal to the auxiliary function f (x)<= g (x, z);
- auxiliary function must touch the surface at the point of support z: f (z)<= g (z, z);

A low dimensional configuration is obtained in this phase.

In the second phase, the final individual configurations obtained from each judge, which are invariant to rotation, reflection and translation are submitted to Generalized Procrustes Analysis (GPA) in order to align the different configurations and obtain a consensual configuration through admissible rigid transformations. The final configurations are aligned according to a criterion of coordinate error minimization.

According to Brombin and Salmaso (2009), GPA is a statistical shape tool. The term shape is defined by the authors as associating the geometric properties of a configuration of points that are invariant to changes in translation, rotation, and scale. Direct analysis of a set of points is not ideal because of the presence of systematic errors, such as position, orientation and size, and GPA is usually used to conduct reliable statistical analysis, eliminating factors that are not related to the shape and aligning the configurations for a system of common coordinates.

GPA is a multivariate statistical technique involving three empirical dimensions: the objects studied, the people judging the objects, and the attributes by which the objects are judged. GPA is ideal for analyzing data from different individuals according to Dijksterhuis and Gower (2010).

The transformations allowed in GPA are translation, rotation/reflection, and isotropic scaling, so that the relative distances between the objects remain unchanged as cited by Rodrigue, (1999).

Gower (1975) proposed an algorithm for the iterative solution of GPA, which has the following steps:

- Centralize each input matrix and then scale it by a constant

$$\rho = \frac{m}{\sum_{j=1}^{m} tr(X_j^T X_j)}$$

where m is the number of configurations.

- Using the centered and scaled configurations, rotate X2 to X1, ($X2 * H$, H is obtained by svd decomposition of $X_2^T X_1$) and compute Z as the average of the two the current configurations, ($\frac{X1+X2*H}{2}$). The configuration X3 is then rotated to Z. Z is then updated. This procedure is used until the final configuration is reached. The final value of Z is named the Configuration or space consensus.
- Calculate the sum of squared residuals as $S_r = m\left(1 - tr(Z^T Z)\right)$ and adjust $\rho_0 = 1 (j = 1, \dots, m)$;
- For j = 1,..m, rotate the current configuration to adjust Z, calculating $\rho_j X_j H_j$, where H is the rotating matrix. Calculate then, Z^* as the mean of X_j and $S_r^* = S_r - m(Z^{*T} Z^* - Z^T Z)$. Make $S_r^{**} = S_r^*$.
- If the change in residuals $S_r - S_r^{**} \geq \zeta$, adjust $S_r^{**} = S_r^*$, and go back to 4.

This step is repeated until the criterion of tolerance is achieved, usually 0.0001.

In the third phase of MDSvarext, clusters shall be generated using the non-hierarchical K-means method, which seeks to maximize the distance between different clusters and to minimize the intra-cluster distances.

The K-means algorithm follows the formulation by mathematical programming, referred by Webb (2002).

$$Min \sum_{i=1}^{n} \sum_{c=1}^{k} z_{ic} \left[\sum_{j=1}^{p} (x_{ij} - m_{cj})^2 \right]^{\frac{1}{2}} \quad (2)$$

$$ST. \sum_{c=1}^{k} Z_{ic} = 1, i = 1, \dots, n$$

$$Z_{ic} = \begin{cases} 1, & if\ instance\ i\ belongs\ to\ cluster\ c \\ 0, & otherwise \end{cases}$$

Where in

$$m_{cj} = \frac{\sum_{i=1}^{n} z_{ic}\ x_{ij}}{\sum_{i=1}^{n} z_{ic}} \quad c = 1,\dots,k \ \text{ and } \ j = 1,\dots,p$$

In which m_{cj} is the cluster´s centroid *c* in dimension *j*, *k* is the number of clusters and *p* the number of dimensions considered.

After separation of the judges into clusters, the algorithm MDSvarext obtains the consensus solutions for each group and uses a nonparametric method to estimate the variance-covariance matrices (fourth phase) and to represent the confidence regions for each cluster generated. The Bootstrap method was used, as it is not necessary to hypothesize about the coordinate's probability distribution obtained via MDSvarext.

Bootstrap is based on intensive computation in place of theoretical analysis, providing answers to problems that are too complex for traditional approaches as well as to simpler problems. It has been made a suitable option by the sharp decline in computational costs (Efron; Tibshirani, 1986).

The Bootstrap strategy is implemented by the construction of B random samples of equal size to the original set with replacement. The Monte Carlo algorithm is then executed in three phases:

- A random number generator independently builds a large number of Bootstrap samples, denominated$y^*(1), y^*(2), \dots, y^*(B)$;
- For each Bootstrap sample $y^*(b)$, it evaluates the statistic of interest, such as $\widehat{\Theta}(B) = \widehat{\Theta}(y^*(b)), \quad b = 1,2, \dots, B$
- It calculates the covariance-variance matrix $\widehat{\Theta}^*(b)$

In this work we used B=10.000, in order to ensure the convergence of the real value of the covariance-variance matrix.

b) Clustering Judgment

The metrics used to validate the number of clusters or classes in which data are partitioned can be divided into two major groups: Internal and stability, as proposed by Brock et al. (2008).

For the purposes of this work we selected only internal validation metrics. We selected measures that reflect compaction, connectivity and separation of the generated clusters. Connectivity refers to the extent to which an instance is allocated to the same cluster of its immediate neighbors. Compaction evaluates the homogeneity of cluster usually calculated with intra-cluster variance, while separation quantifies the degree of separation of clusters, usually by measuring the distance between centroids. Since compaction and separation have opposite tendencies, namely, compaction increases with the number of groups, and the separation decreases, one option is to combine the two metrics. Two measures that represent a non-linear combination of compaction and separation are represented by Dunn index and Silhouette's width. (Everitt *et al.*, 2001)

The connectivity is defined by:

$$con(C) = \sum_{i=1}^{N} \sum_{j=1}^{M} x_{i,} nn_{i(j)} \qquad (3)$$

where N represents the total number of observations or instances and M is the number of dimensions.

$nn_{i(j)}$ is the *j-th* nearest neighbor of instance *i* in dimension *j*, and $x_{i,} nn_{i(j)} = 0$ if *i* and *j* are in the same cluster and 1/j otherwise.

Connectivity range is $0 \leq \mathrm{con(C)} \leq \infty$, and it is a metric that should be minimized, that is, the lower the value the better the structure proposed by the algorithm, as cited by Everitt *et al.* (2001).

The Dunn index is the ratio of the shortest distance between instances that are not in the same cluster and maximum distance intra-cluster. The Dunn index value varies from 0 to 1 and the closer to 1 the better the result, according to Brock *et al.* (2008).

The Silhouette's width was proposed by Kauffman and Rousseeuw, (1990) and recommended by Everitt et al. (2001). For each instance *i* an index S(i) ∈ [-1,1] is calculated. S(i) measures the difference between b(i) and a(i), where a(i) is the mean dissimilarity of instance *i* in relation to their cluster and b(i) is the average dissimilarity of the instance *i* for all instances in the nearest cluster. When S(i) is close to 1 instance *i* is closer of its cluster than to the nearest neighbor cluster, and thus represents a good allocation. When S(i) is close to -1, the instance is poorly allocated. The authors of the proposal also indicates that values above 0.5 represent a good result and values below 0.2 may indicate the absence of clear structure of the data. Finally, Everitt et al. (2001) warn that it is not prudent to rely on only one of the metrics to select the optimal number of clusters.

III. Results

In order to verify the results obtained by the MDSvarext we collected data to establish the multiple perceptual map. The main objective was to assess the perception of a focal group of safety engineer´s students regarding occupational risks. For this purpose a questionnaire was applied. The questionnaire listed 10 objects. The objects represent occupational risks that are classified into two major groups: physical and chemical agents as shown in Table 1. For each object the respondents were asked to assign scores on a Likert scale from 1 to 7 in nine dimensions, as Table 2. The forms provided to respondents contained objects arranged in a random way, aiming to eliminate any possibility of systematic error in data collection. Respondents were only given instructions on how to fill the form, using the Likert scale, with no explanation of the meaning of each object. The focal group comprised 14 students from a Safety Engineering course.

Table 1 : Objects for Occupational Risk Perception Study

Physical Agents	Chemical Agents
Noise	Silica
Heat	Lead
Vibration	manganese
UV radiation	Benzene
	mercury
	Nano materials

Table 2 : Dimensions of risk perception and their Likert scales, according to Sjoberg, Bjorg-Elin and Rundmo, (2004).

Dimensions	Scale
Willingness to risk.	Voluntary Involuntary
People "take" this risk voluntarily	1 2 3 4 5 6 7
Time to Effect.	Immediate Late
To what extent there is risk of immediate death or the risk of death is delayed.	1 2 3 4 5 6 7
Knowledge of Risk. – Exposed.	Known Not Known
To what degree the risk is known by people who are exposed to it.	1 2 3 4 5 6 7
Knowledge of Risk. - Science	Known Not Known
To what degree the risk is known to science.	1 2 3 4 5 6 7
Control of Risk.	Incontrollable Controllable
If you are exposed to risk, to what extent you can, because your skills, avoid death while engaged in activity.	1 2 3 4 5 6 7
Newness.	New Old
This threat is new or old, familiar	1 2 3 4 5 6 7
Chronic-Catastrophic.	Chronic Catastrophic
This risk kills one person at a time (chronic) or risk kills a large number of people at once (catastrophic)	1 2 3 4 5 6 7
Common-Feared.	Common Feared
People have learned to live with this risk and may decide to quietly about the same, or is a risk that people have a great fear	1 2 3 4 5 6 7
Severity of Consequences.	Not Fatal Fatal
What is the likelihood that the consequence of that risk is fatal	1 2 3 4 5 6 7

The raw matrices, with 10 objects and 9 dimensions, obtained from students were then submitted to MDSvarext. The first checkpoint is to verify what is the ideal number of dimensions. Usually 2 or 3 dimensions are recommended for better visualization of data.

Figure 1 shows the Scree Plot of the adjustment of Stress function and dimension. What can be seen is that for two dimensions we obtain the greatest decrease in stress function, thus, this is the dimension to be adopted for data representation.

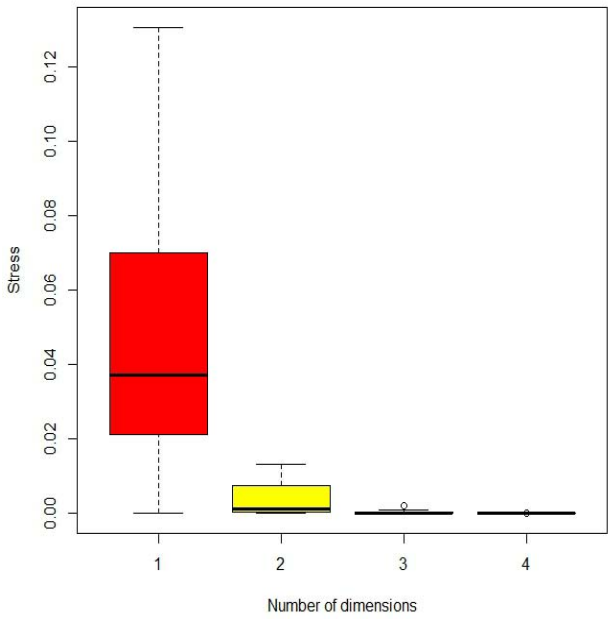

Figure 1 : Scree Plot for MDS-SMACOF

The SMACOF solution was obtained with SMACOF package of statistical software, R, version 2.15.0. implemented by De Leeuwn and Mair (2009). GPA was performed using the statistical software R and the SHAPES package written by Dryden, (2009).

After running the algorithm MDSvarext the perceptual maps obtained can be seen in Figures 2 and 3.

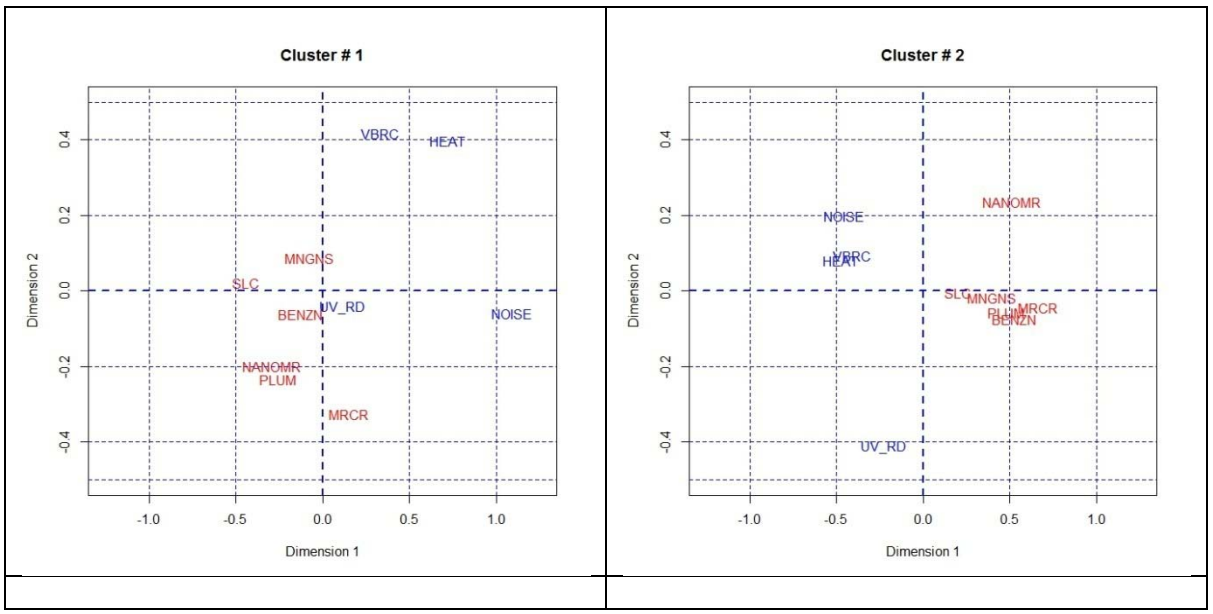

Figure 2 : MDSvarext solution – Cluster #1

Figure 3 : MDSvarext solution – Cluster #2

The clustering process generated two perceptual maps. These clusters have different interpretations, but overall both groups perceive the physical and chemical hazards as different. As can be seen in Figures 2 and 3 groups are on different sides in the generated maps. One exception is "mercury" in cluster 1.

The number of generated clusters was validated with the assistance of clValid package implemented on software R by Brock, (2011). The results are shown in Table 3.

Table 3 : Results of internal validation using clValid package

Clustering Methods/ Metrics	Optimal # of clusters	hierarchical	Optimal # of clusters	kmeans
Connectivity	2	3.8579	2	3.8579
Dunn	2	1.4407	2	1.4407
Silhouette	2	0.7115	2	0.7115

We can extract from Table 3 that the results obtained with two different clustering algorithms, one hierarchical and the other non-hierarchical, the last one proposed to run along with the algorithm MDSvarext. In both cases the optimal number of clusters to be generated was two.

Finally the last phase of the algorithm generates the confidence regions using a nonparametric technique, Bootstrap. To demonstrate the solution obtained for the two clusters, we selected only two risks. They are on opposite sides of the map, and belong to different groups of risks. The depiction of only two risks has the sole purpose of generating a clean map.

In Figure 4 it could be seen the confidence regions representation for "NOISE" and "MANGANESE" in cluster 1. What can be observed is that the two risks are perceived differently for cluster 1.

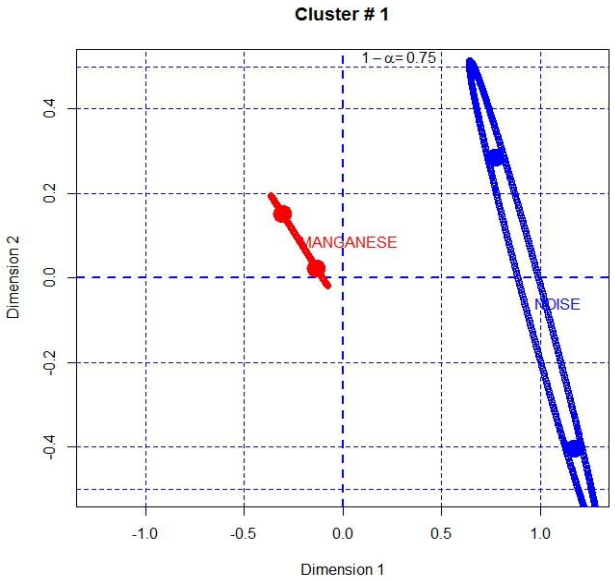

Figure 4 : Confidence Regions, for cluster 1, α=0.25

Figure 5 shows the result for cluster 2.

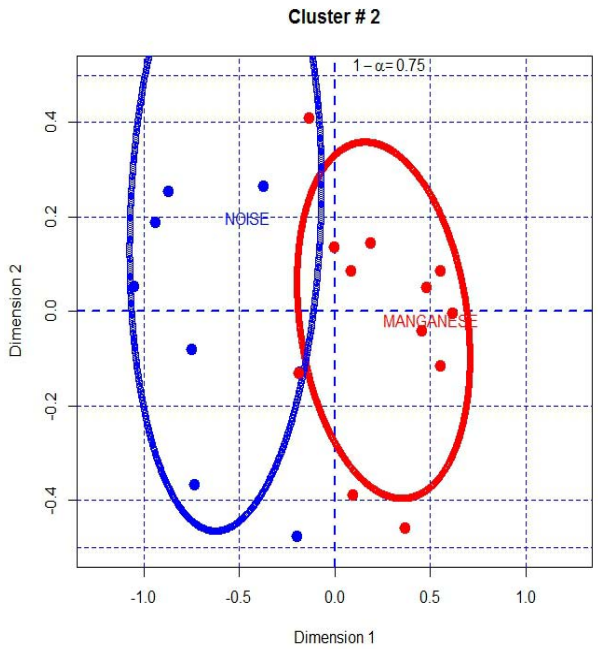

Figure 5 : Confidence Regions, for Cluster 2, $\alpha=0.25$.

The students belonging to cluster #2 were not able to discriminate the two risks statistically, as can be seen by the overlapping ellipses.

It should be emphasized that this analysis using focal group, with only 14 students, or sometimes even less is quite usual due to the costs for obtaining a very large sample. And the method proposed is suitable from the statistical point of view, to deal with small samples.

IV. Conclusions

The main conclusion of this paper is that perceptual maps generated from individual subjectivity analysis have large variance due different perception inherent to a focal group. The proposed MDSvarext deals with that problem by generating more than one perceptual map, which reduces variability by splitting the data in more homogeneous subgroups. This finding could help researchers to better interpret data from subjectivity studies.

The problem of optimal number of clusters to be generated is not overcome, and more efforts should be done in order to fulfill this gap, but it is beyond the scope of this paper.

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Empirical Methods of Capacity Estimation of Urban Roads

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In this paper an attempt is made to study the fundamental details of traffic flow and evaluate the capacity of urban mid block section, particularly for a two lane divided cross section. The traffic data at ten locations in Chennai city was collected through video graphic survey. Detailed extraction of traffic headway (inter arrival time), volume and speed were made for every 5 minute time interval, covering both the peak and non peak period. Using the fundamental parameters, capacities of sections were evaluated by three methods, namely Headway method, Observed volume method and Fundamental diagram method.

Detailed analysis of the arrival pattern of vehicles was made and appropriate distribution identified to get the mean headway. The Selected Maxima method assumes that the capacity state is reached during the survey period. As against the normal time slice of 15 minutes, a 5 minute time slice was considered for identifying the peak flow rate. In the third approach, a plot was made between traffic flow in PCU and the speed, to compare the relationship. Since the data was scattered, the enveloping curve technique was adopted, even though the usual pattern of speed flow curve is parabolic.

Keywords: urban roads – heterogeneous traffic – headway – volume – fundamental diagram – empirical methods – capacity.

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Empirical Methods of Capacity Estimation of Urban Roads

Mr. V Suresh [α] & Dr. G Umadevi [σ]

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The average capacity of a standardized two lane 7m) urban mid block road section was found to be 5649, 5336 and 5146 PCUs by the headway, volume and fundamental diagram methods respectively. It is observed that the capacity values are much higher than the recommended values by Indian Roads Congress (IRC). The reason for this is mainly due to the Passenger Car Equivalent values adopted for different category of vehicles, as recommended by IRC, which requires to be studied in detail.

Keywords: urban roads – heterogeneous traffic – headway – volume – fundamental diagram – empirical methods – capacity.

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I. Introduction

Determination of the capacity of roads is a major issue in the analysis of transportation flow. The capacity of a road is defined as the maximum number of vehicles, per unit time, which can be accommodated under given condition with a reasonable expectation of occurrence.

The capacity and other flow characteristics depend heavily on driver behaviour and the traffic composition. It also depends on the physical and environmental conditions such as the geometric design of facilities, the weather and the lighting. Capacity is only a probabilistic measure. There are variations from time to time and place to place in the maximum number of vehicles that can be accommodated by similar facilities. All the variations cannot be accounted for accurately by the normal determinants of capacity. Since there will be random variation in the number of vehicles that can be accommodated over very short time interval, the capacity is best thought of as the maximum average flow rate that can be sustained.

II. Need and Objective

The literature on road capacity is very diverse. Many developed countries, like USA, UK, Japan, Australia, Sweden, China, and Indonesia have developed capacity manuals. The US highway capacity manual has prepared several graphical and mathematical forms to take care of most of the important parameters affecting the capacity. However, India still does not have a comprehensive capacity manual for our roads. Based on the limited studies carried out so far, the Indian Roads Congress (IRC) has suggested service volume for different categories of urban roads (IRC 106, 1990). An attempt is made in this study to estimate the capacity of urban mid block sections, more particularly, of two lane (divided) roads. In doing so, the basic parameters of flow like headway (inter arrival time), volume and speed are studied and used to estimate the capacity by various direct empirical methods.

III. Literature Review

According to Taylor and others (Taylor, 1998), video techniques have the potential to provide a cheap, quick, easy and accurate method of investigating traffic

systems. Video tapes of traffic counts contain much more information than what the manual recorder can collect.

Isaac and Veeraraghavan (Isaac, 1995) have attempted to study the headway distribution under mixed traffic flow conditions. Various distribution models like Negative exponential. Shifted negative exponential, Erlang, Log-normal, Double exponential (Schul's model) and Tripple exponential models were tried and they have reported that no definite conclusion can be arrived regarding the suitability of the models for different volume levels and the percentage composition of vehicle types. It is also reported that the variation in width of the road do not have influence on the distribution. The study has also suggested that the exponential distribution (for flow less than 500 vph), Shifted exponential distribution (for 500 – 2000 vph) and Erlang or composite distribution (for 2000 to 3000 vph) may be adopted for a mixed traffic flow (for a composition of about 20% of 4-wheerlers. 30% autos and 50 % two wheelers):

A study by Chang and Kim (Chang, 2000) has analysed the quantitative methods to define capacity by evaluating the headway and volume distribution from observed traffic flow. Statistical distributions of observed traffic flow were used to remove long headways and reduced cumulative distribution of volumes was only considered. The authors have concluded that the rational alternative is to take the 95 % cumulative distribution of observed traffic flow, eliminating 5 % of long headways.

Reddy and Issac (Reddy, 1995) have attempted to calculate the practical capacity values of some selected sections on urban roads based on headway analysis. The practical capacity has been calculated based on weighted mean, median, mode and lower mean headway of different classes of vehicles at different volume levels. It was observed that negative exponential distribution was found to be fitting well for vehicle volume less than 720 vph, whereas Erlang distribution fitted well at higher volume level of 1440 to 2880 vph.

Hoogendoorn and Bovy (Hoogendoorn, 1999) have extended the generalised queueing model (GQM) to headway observations, segregated according to vehicle type. The estimation method developed is based on the minimization of an integrated squared error distance in the frequency domain. In the study, a new approach for modeling mixed- vehicle- type headway distributions was adopted. The model is a straightforward modification of the GQM and distinguishes among different vehicle types (eg. Passenger cars, articulated trucks, unarticulated trucks, recreational vehicles, motorbikes). It was expected that because of differences in driving behaviour among vehicle types, bike-type specific headway distributions will exhibit different parameter values.

Arasan and Koshy (Arasan, 2003) have reported that the negative exponential distribution is adequate to model headways. It was observed that even during medium and heavy flow conditions, the flow is unconstrained for a considerable proportion of smaller vehicles (two wheelers) and thus their arrivals are in the random state.

Katti and Pathak (Katti, 1985) has analysed various headway distribution models for urban roads under mixed traffic conditions. It was observed that opportunities for passing depend upon the width of the road and vehicle size, which has direct influence on the choice of the headway model.

According to Chandra (Chandra, 2001), the exponential and log-normal distributions are not able to describe headway distribution under mixed traffic conditions. The hyperlang distribution was found to be sound and quite versatile for this purpose and can be fitted to a wide range of traffic volumes.

The case study of time headways from Riyadh (Al-Ghamdi, 2001) indicate that though observed headways at arterial sites follow a Gamma distribution, distributions that fit freeway headways differ according to the traffic flow state. The Erlang distribution was found to provide a good fit to the observed headway at sites with high traffic flows.

It can be seen that different studies have found various distribution to describe the traffic pattern on roads.

IV. Methodology

There are different methods of estimating the capacity values. Based on the data used and the strategy adopted, the methods are classified as direct empirical and indirect empirical methods (Minderhound, 1997). The basic data that are required for estimation of capacity are roadway width, headway, volume, speed and density. In the direct empirical methods, the observed data are used to estimate the capacity directly. However in the case of indirect methods, the observed data are calibrated and computer programmes developed for estimation of capacity. Sophisticated simulation models have been developed to predict the flow characteristics and to estimate the capacity by many researchers. In the context of Indian urban roads, the understanding of the traffic flow is very limited due to the following reasons; the influence of various types of vehicles sharing the carriageway, the behaviour of drivers, lack of awareness and adherence of traffic rules, non standard lane widths, bad road surface conditions etc. Unless a detailed study is carried out along the lengths and breadths of our country to understand and model the various parameters of traffic flow and other impedance of flow, the simulation model approach may not be accurate to predict the capacity. Since the direct empirical methods are less cost

intensive and can give capacity value to the desired accuracy, it is felt that the direct empirical methods are the more appropriate way of estimating the capacity of roads for Indian conditions.

Depending on the availability of time, manpower and cost, several methods are available to estimate the capacity of roads. The different approach requires various data from just the carriageway width to volume, speed and density of traffic at a particular location. In this attempt the following three approaches were considered to estimate the capacity:

- Headways
- Volume
- Volume and Speed (Fundamental diagram)

a) Headway

Headway is the time separation of vehicles in the traffic stream and is usually measured in fraction of a second. Headways are measured between common points or successive vehicles; time gap are measured from the rear of one vehicle to the front of the next. The distribution of these headways has long been a subject of study. Even though several attempts have been made to find the distribution of headways under homogeneous traffic following lane discipline, the studies under mixed traffic conditions are very few. The distribution tried for flow under homogeneous conditions include negative exponential, shifted exponential, gamma, erlang, log-normal etc for varying traffic volume.

For traffic under mixed conditions, exponential, erlang, normal and log-normal distributions for various volume levels have been attempted. In the context of the Indian urban traffic flow conditions, it would be appropriate to consider the full road width, instead of individual lanes for the study since all vehicles are free to use any part of the carriageway. The capacity at a cross section of the road can be estimated with the reciprocal of the mean time headway of the vehicles as given below:

Q= 1 / h (vehicles per second) or Q = 3600 / h (vehicles per hour).

The advantage of this model is that only headways at one cross section of the road at intensity below capacity are required. It is not necessary to wait for a traffic state at about capacity level.

b) Volume

Capacity estimation by this method is made solely with the observed traffic volume. In the observed extreme value method, the estimation of capacity is by using known maximum traffic volumes observed over a period of time. The data to be used for this Selected Maxima method is the hourly traffic volume of flow rates observed in an averaging interval of less than one hour (either 15 mts. or 5 mts. intervals). The basic assumption of this method is that the capacity state of the road is reached during the survey period. The capacity q_c is assumed to be equal to the maximum traffic flow observed during the observation period.

c) Volume and Speed (Fundamental Diagram)

This approach is based on the basic stream flow diagram or Fundamental diagram. The existence of relationship between the two important variables namely traffic volume and harmonic mean speed is used to estimate the capacity. The traffic characteristic, Flow (q) is defined as the number of vehicles passing a specific point or short section in a given period of time, which is expressed as hourly rate (vph). One unique flow parameter is maximum flow or capacity (q_{max}). Speed (u) is defined as the average rate of motion and is expressed in km / hr. In this study, the main focus is on the mid block sections with no obstructions for flow of traffic. Hence the speeds are measured using spot speed technique where the time taken to cover the predetermined length was recorded. The spot speeds are usually higher than the average stream speed, since there are no delays in the short distance of the mid block. From the speed-flow diagram, the flow corresponding to the maximum flow is taken as the Capacity (q_{max}).

V. Data Collection

The data for the present study was collected at ten mid block sections of four lane divided (2 lanes on either side) roads in Chennai city. The video recording technique was used to collect the data because of its advantages over the manual and conventional method of collection. A reconnaissance survey was done initially to select the site. The mid block stretches selected were straight, level and free from any obstructions / restrictions to traffic movement. There were raised foot path on either sides and the divider was fixed. The road stretches were selected so that the carriageway widths varied from 6.5 m to 9.0 m. The road links were identified based on the traffic and their characteristics. To have a good representation of the whole study area, i.e. the Chennai city, the road stretches were selectively chosen from the three parts of the city ie. South, North and Central. Based on the city road map and discussion with experts, the first list of locations was drawn. A reconnaissance survey of all the road links was made to see the actual site conditions and the geometrics. The exact survey locations were frozen after ascertaining that the flow is even and the stretch is divided for a substantial length without any obstructions like bus stops, signals. The survey locations are shown in Figure 1. The video camera was placed at vantage points near the survey locations to collect the data. A longitudinal trap length of about 30 m was adopted to capture the data for the measurement of speed. Markings were made with paint on the road to fix the trap length. The video camera was mounted on the tripod stand and was

placed at a sufficiently high level so as to cover the full survey stretch. The data collection was done on normal sunny days (working days between Mondays through Friday). The surveys were carried out for 5 hours between 7 am and 12 noon, sufficiently long duration to cover both peak and off peak traffic. The timer in the camera was switched on to have the time recorded.

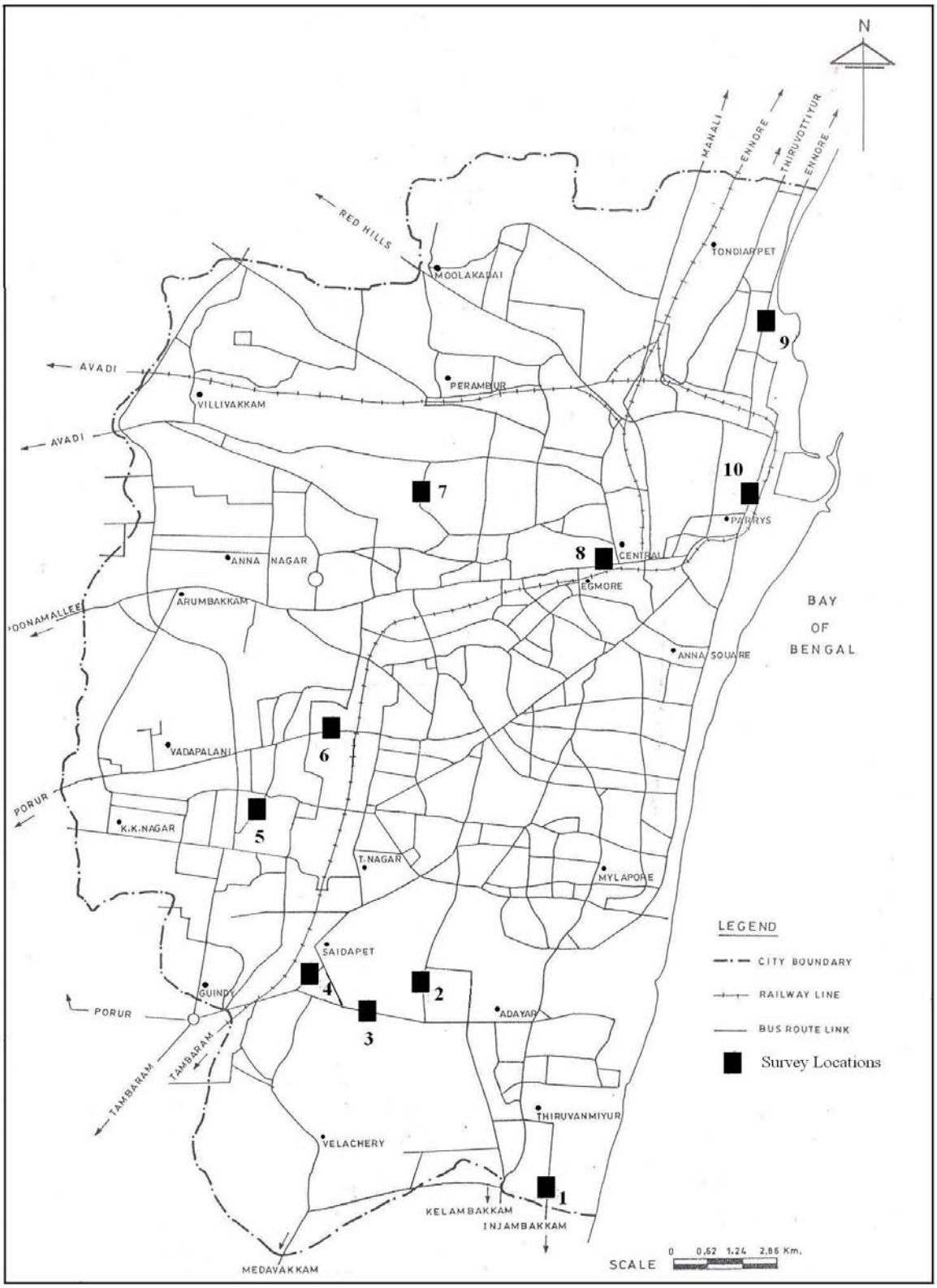

Figure 1 : Location of Points Selected for Video graphic Survey

In addition to the traffic data the physical data like carriageway width, footpath width, and adjoining land use were collected at the survey locations.

VI. Data Synthesis

The data collected at the site on video tapes were converted into video files and copied on to a CD. Using the "Timeint" computer programme, which records the arrival of the vehicle at the section at the stroke of a key, the inter arrival time was recorded up to 2 decimal places of a second and stored as file. The CD was run several times for creating volume/headway data files for the entire survey period for each category of vehicle. Counts were classified as heavy vehicles (lorry and tankers), buses (both private and metropolitan public transport buses), LCV (Passenger van, goods carriages and maxi cabs), cars, autorickshaws, powered two wheelers and cycles (including other slow moving vehicles). Using a stop watch the time taken by each category of vehicle to pass the road stretch marked at the survey location was recorded for the entire survey period. The data for speed estimation was analysed for sample data, which was not less than 25 percent of the total volume, to get the average speed of the traffic stream and for individual category of vehicle in each five minute time interval.

Capacity estimation by the three different methods mentioned above was carried out to identify the most appropriate method. The road names, carriageway width, peak hour, peak hour traffic (Nos. and PCU) are given for all the 10 survey locations in Table 1. The road stretches are identified by location number 1 to 10. The carriageway width of the road stretch at the survey locations varied from a minimum of 6.5 m at Location 1 and 10 (East coast road and Manarsami koil road) to a maximum of 8.9 m at Location 4 (Anna road). The composition of the traffic stream is also a critical parameter in heterogeneous flow conditions. The traffic compositions at these locations are given in Table 2. Analysis of the peak hour data indicate that the motorized two wheeler is the major component accounting for more than 50 per cent of the total traffic. The percentages of cycles (including other slow moving vehicles) vary from 5.3 percent to 19.03 percent at the selected locations. The combined percentage shares of large sized vehicles (bus, lorry and light commercial vehicles) vary from 1.2 percent to 5.7 percent of the total vehicles. The observed number of categorized vehicles was converted into equivalent PCU by adopting the values recommended by Indian Roads Congress. The peak hour traffic was observed to be lowest at Location no. 9 (Manarsami koil road) with 3360 PCU and highest at Location no. 4 (Anna road) with 8879 PCU.

Table 1 : Effective Carriageway Width and Peak Hour Volume Details

Road name	Loc No.	Road Width (m)	Peak Hour	Peak Hour Volume in Vehicles	Peak Hour Volume in PCU
East Coast Road	1	6.5	8:30 – 9:30	3993	3733
Gandhi Mandapam Road	2	7.5	9:00 – 10:00	5021	4134
Sardar Patel Road	3	8.5	8:45 – 9:45	6252	5090
Anna Road	4	8.9	9:00 – 10:00	9975	8879
Ashoknagar IV Avenue	5	8.5	8:45 – 9:45	4346	3599
Arcot Road	6	7.45	8:45 – 9:45	7079	6091
Medavakam Tank Road	7	7.1	9:00 – 10:00	6370	4929
Periyar Road	8	8.6	9:45 – 10:45	5694	6085
Manarsamy Koil Road	9	6.7	9:00 – 10:00	3186	3360
North Beach Road	10	6.5	9:15 – 10:15	4330	4327

Source : Survey Analysis

Table 2 : Composition of Traffic in Per Cent (Peak Hour)

Loc. No.	Bus	Lorry	LCV	Car	Auto	Two wheeler	Cycle	Total
1	0.88	0.68	2.05	16.65	12.10	52.17	15.48	100
2	0.30	0.34	0.90	19.92	7.37	63.83	7.35	100
3	1.63	0.74	1.62	13.88	7.17	55.93	19.03	100
4	1.35	0.67	1.80	12.99	10.39	67.49	5.30	100
5	0.39	0.39	1.73	14.36	8.58	59.69	14.86	100
6	1.10	0.21	1.40	11.99	10.41	58.57	16.32	100
7	0.53	0.13	0.53	6.55	8.48	66.26	17.52	100
8	1.33	1.02	2.28	16.84	20.06	51.86	6.60	100
9	1.54	1.07	1.85	4.65	21.72	59.95	9.23	100
10	2.79	1.39	1.57	6.81	15.27	63.65	8.43	100

VII. Capacity Estimation

a) Headway

Most of the studies done on analysis of headway distribution have examined vehicular flow in the range from 400 vph up to a maximum of 3000 vph only. However the traffic volume on the selected roads (two lane - divided) in Chennai during the peak hour varies from 3186 to 9975. The average headway (of all vehicles) at the 10 locations during the full survey period covering both the peak and off peak period is shown in Figure 2. It is evident that the headway is minimum during the peak period.

To anlyse the data, the Bestfit statistical windows programme was used. For the given data set, the software finds the distribution that fits best. More than 20 different distributions are tried to determine the distribution that best fits the data. It performs three standard tests to determine goodness of fit: Chi-square, Anderson – Darling and Kolmogarov – Smirnov.

The peak hour headway (inter arrival time) data of all vehicles were fitted for evaluating the most appropriate distribution. The total data obtained from the field were fitted to get the best distribution. Also, as suggested by Chang and Kim, the headway data set was grouped in appropriate class intervals and the cumulative distribution done. The headway data above 95 % of the cumulative distribution were removed to eliminate long headways. The distribution which fits the data under both the conditions (with all data and without long headways) is shown in Table 3. It is seen that except for two locations, there is change in the distribution model selected in the case of data set without long headways.

It is seen that no particular distribution fits for all the ten headway data sets. The distribution models at all the selected locations with the estimated values for the parameters are shown in Table 4. For the lowest peak hour flow of 3186 vehicles (Location No. 9 - Mannarsami Koil Road), the headway was found to follow Inverse Gauss distribution model and for the highest peak hour flow value of 9175 vehicles on Anna Road (Location No. 4), it was found to have a Triangular distribution model.

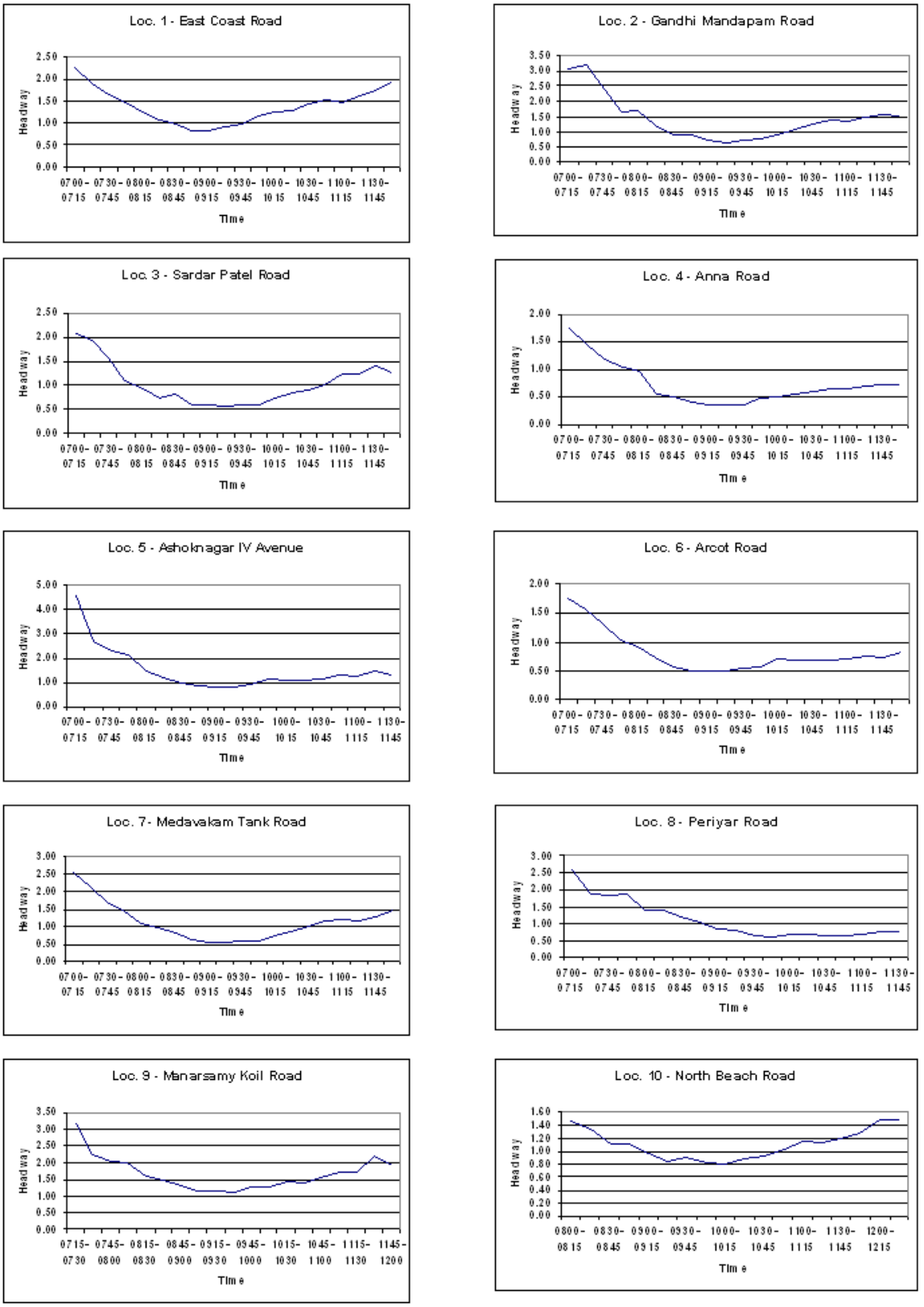

Figure 2 : Average Headway of Vehicles at the survey locations

Table 3 : Headway Model With and Without Long Headway

Loc. No.	With all Headway Data	Without Long Headway Data
1	Gamma	Weibull
2	Pearson 5	Pearson 5
3	Log Log	Inverse Gauss
4	Pareta 2	Triangular
5	Pearson 5	Log Normal 2
6	Exponential	Weibull
7	Inverse Gauss	Exponential
8	Log Normal 2	Beta General
9	Inverse Gauss	Inverse Gauss
10	Log Normal 2	Pareto 2

Source : Survey analysis

Table 4 : Statistical Details of Best Headway Model at all Locations

Loc. No.	Best model	Mean	Standard. Deviation.	Equation
1	Weibull	0.717	0.597	(1.2092, 0.7654)
2	Pearson 5	0.576	0.567	(4.9937, 3.9207)
3	Inverse Gauss	0.425	0.374	(0.5357, 1.0986)
4	Triangular	0.351	0.248	(0,0, 1.0542)
5	Log Normal 2	0.814	0.877	(-0.4256, 0.8117)
6	Weibull	0.417	0.363	(1.1641, 0.4438)
7	Exponential	0.455	0.454	0.4549
8	Beta General	0.481	0.432	(0.7113, 2.3117)
9	Inverse Gauss	1.071	1.281	(1.206, 1.0686)
10	Pareto 2	0.615	0.724	(3.7887, 7.1570)

Since there is no single distribution model that fits the data at various locations, it was decided to analyse the best three fittings for each location. Table 5 shows the best three distribution models that fits the data. It is seen that out of 10 locations, the headway at 7 locations reasonably follow Log Normal 2 distribution model and at 5 locations the Inverse Gauss distribution model was found to be acceptable. For the two locations (Location No. 7 and 8), the exponential distribution model was found to be acceptable. Hence, it is inferred that for high volume mid block traffic flows, the following three distribution models are acceptable: 1. Log normal-2; 2. Inverse Gauss and 3. Exponential.

Table 5 : Three Best Headway Models (without long headways)

Loc. No.	Best	Second best	Third best
1	Weibull	Beta General	Inverse Gauss
2	Pearson 5	Log Normal 2	Inverse Gauss
3	Inverse Gauss	Log Normal 2	Exponential
4	Triangular	Extreme value	Log normal 2
5	Log Normal 2	Inverse Gauss	Erlang
6	Weibull	Log Normal 2	Inverse Gauss
7	Exponential	Pareto 2	Pearson 5
8	Beta General	Weibull	Exponential
9	Inverse Gauss	Log Normal 2	Pareto 2
10	Pareto 2	Beta General	Log normal 2

Source : Survey analysis

Using the identified distributions, the estimated mean headway of all the three distribution models and the average of the mean at all the ten locations are given in Table 6. The average headway varies from 0.317 seconds at Location No. 4 (Anna Road) to 1.074 seconds at Location No. 9 (Manarsami Koil Road). The estimated total capacity of each road section using the average mean value is given in column 4. Based on the composition of the traffic at each location, the number of vehicles has been converted into equivalent PCU. Since the width of the carriageway is varying, the capacity is normalized for a standard 7 m two lane width using the following equation:

$$NC = \frac{TC * SW}{CW}$$

Where NC – Normalised capacity; TC - Total Capacity
CW - Carriageway width of the section (m)
SW - Standard width of 7 m.

The normalized value for the standard two lane carriageway width (7 m) is shown in the last column. The estimated capacity varies from a minimum of 2979 PCU to 8340 PCU. Based on the observed headway, the average capacity of a two lane urban road was estimated to be 5649 PCU.

Table 6 : Capacity Estimation by Headway Model

Loc. No.	Mean Headway			Average of Mean Headway	Total Capacity in Vehicles	Total Capacity in PCU	Normalised Capacity in PCU (7 m)
	I	II	III				
1	0.717	0.719	0.717	0.718	5016	4716	5079
2	0.425	0.428	0.425	0.426	8451	6881	5666
3	0.576	0.575	0.568	0.573	6283	5167	4822
4	0.351	0.296	0.305	0.317	11345	10603	8340
5	0.814	0.802	0.802	0.806	4467	3617	2979
6	0.417	0.424	0.419	0.420	8571	7691	7227
7	0.455	0.455	0.459	0.456	7889	6104	6018
8	0.481	0.481	0.482	0.481	7479	7992	6505
9	1.071	1.082	1.069	1.074	3352	3522	3679
10	0.615	0.613	0.656	0.628	5732	5729	6170

Source : Survey analysis. *All headway values in seconds*

b) Volume

The peak hour data was further analysed to estimate the capacity flow conditions. The flow in each 5 minute time interval for each category of vehicles were extracted and the equivalent PCU calculated based on the recommended values by IRC. The maximum flow in any 5 minute interval was identified. This peak flow rate is multiplied by a factor 12 to estimate the capacity flow per hour. The normalized capacity value for a standard width of 7 m was also estimated. Similar exercise for other locations was done and the details are given in Table 7. The maximum and minimum capacity values obtained by this method were 8258 PCU and 3310 PCU respectively. The average capacity by this approach was found to be 5336 PCU.

Alternatively, the average of three highest values was considered while estimating the capacity. The three maximum flows in 5 minute interval at the location were identified. The peak flow rate (maximum flow in 15 minutes) is then multiplied by 4 to get the peak flow per hour. The normalized value for the standard two lane carriageway width (7m) is then calculated. The details at all the ten locations are given in Table 8. By this method, the average capacity was found to be 5075 PCU.

Table 7 : Capacity Estimation by "Selected Maxima" Model (5 min. time slice)

Location No.	Peak Hour Volume in PCU	Max Flow in 5 mts	Total Capacity in PCU	Normalised Capacity in PCU (7m)
1	3733	346	4152	4471
2	4134	466	5592	4605
3	5090	432	5184	4838
4	8879	875	10500	8258
5	3599	335	4020	3310
6	6091	574	6888	6472
7	6085	574	6888	6791
8	4929	515	6180	5030
9	3360	355	4260	4451
10	4327	397	4764	5130

Source : Survey analysis

Table 8 : Capacity Estimation by "Selected Maxima" Model (15 min. time slice)

Location No.	Peak Hour Volume in PCUs	Max Flow in 5 min.			Max. Flow in 15 min.	Total Capacity in PCU	Normalised Capacity in PCU (7m)
		I	II	III			
1	3733	346	346	341	1033	4132	4450
2	4134	466	460	425	1351	5404	4450
3	5090	432	392	367	1191	4764	4446
4	8879	875	775	759	2409	9636	7579
5	3599	335	320	320	975	3900	3212
6	6091	574	549	543	1666	6664	6261
7	6085	574	553	546	1673	6692	6598
8	4929	515	458	453	1426	5704	4643
9	3360	355	309	300	964	3856	4029
10	4327	397	390	390	1179	4716	5079

Source : Survey analysis

There is a drop of nearly 5 per cent in the capacity when the time slice for the peak flow rate was increased from 5 minutes to 15 minutes.

c) Volume & Speed

The volume (in PCU) for each 5 minute block was converted into hourly flow. The speed for each category of vehicles was calculated based on the time taken to move over a fixed length of the carriageway. The speed of Fast moving vehicles alone was considered for analysis since the number of slow moving vehicles is less and the difference in speeds is very large. The weighted average stream speed is calculated taking into account the speed and the number of vehicles in each category during each time interval.

The traffic flow in PCU corresponding to the average speed was plotted to find the relationship between the two. Since the data was very scattered, no regular relationship was fitting. The Enveloping curve technique developed at CRRI, New Delhi and also used by Dr. Satish Chandra was used to determine the capacity of the road. Even though the usual pattern of the speed flow curve is parabolic, for reasons stated earlier, a curve passing through the origin and bounding all the points was drawn for each location. The speed flow graphs for all the ten locations using the enveloping curve method were made and is depicted in Figure 3 to 12. The maximum flow, which is taken as the capacity flow and the normalised value for the standard two lane width, for each location is given in Table 9. By this method, the average capacity was found to be 5146 PCU.

Table 9 : Capacity Estimation by Fundamental Diagram Method

Location No.	Effective Carriageway Width (m)	Total Capacity in PCU	Normalised Capacity in PCU (7m)
1	6.5	3875	4173
2	7.5	4820	4499
3	8.5	5750	4735
4	8.9	10400	8180
5	8.5	3750	3088
6	7.45	6430	6042
7	7.1	5570	5492
8	8.6	6880	5600
9	6.7	4180	4367
10	6.5	4910	5288

Source : Survey analysis

The average capacity of two lane divided (two way) urban mid block was estimated to be 5649, 5075, and 5146 PCU by Headway, Volume and Fundamental diagram methods respectively.

Figure 3. Speed Flow Curve – East Coast Road

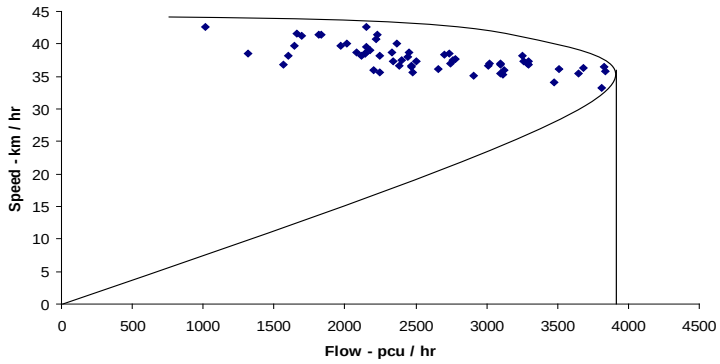

Figure 3 : Speed Flow Curve – East Coast Road

Figure 4. Speed Flow Curve – Gandhi Mandapam Road

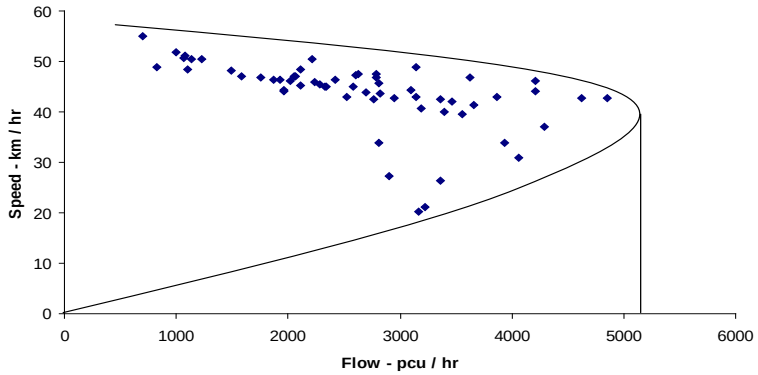

Figure 4 : Speed Flow Curve – Gandhi Mandapam Road

Figure 5. Speed Flow Curve – Sardar Patal Road

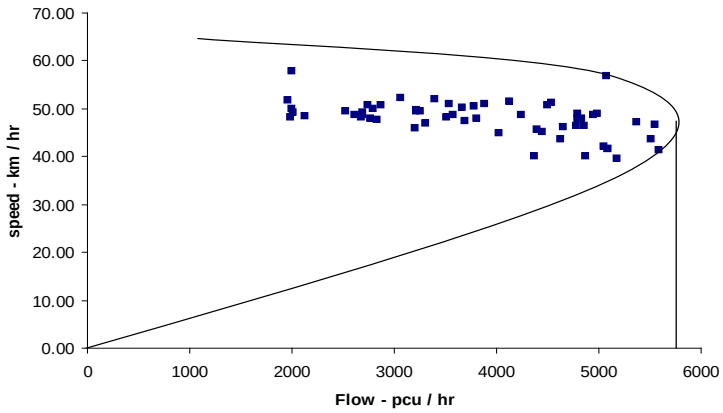

Figure 5 : Speed Flow Curve – Sardar Patal Road

Figure 6. Speed Flow Curve - Anna Road

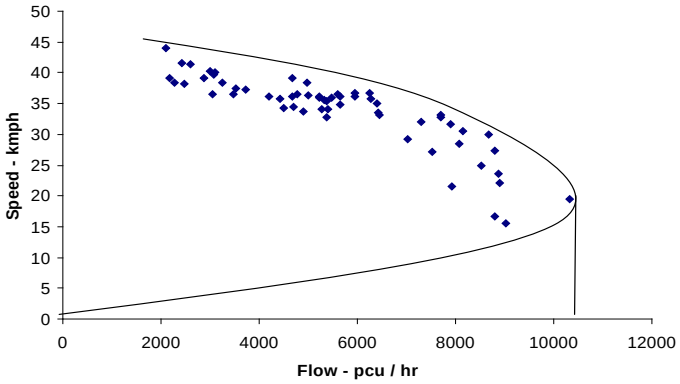

Figure 6 : Speed Flow Curve – Anna Road

Figure 7. Speed Flow Curve – Ashoknagar IV Avenue

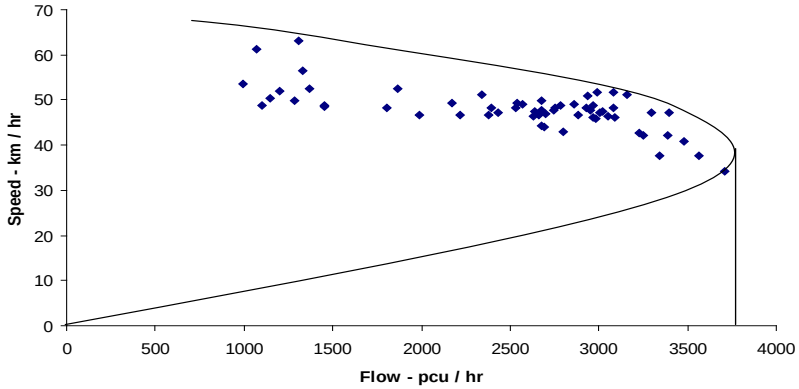

Figure 7 : Speed Flow Curve – Anna Road

Figure 8. Speed Flow Curve - Arcot Road

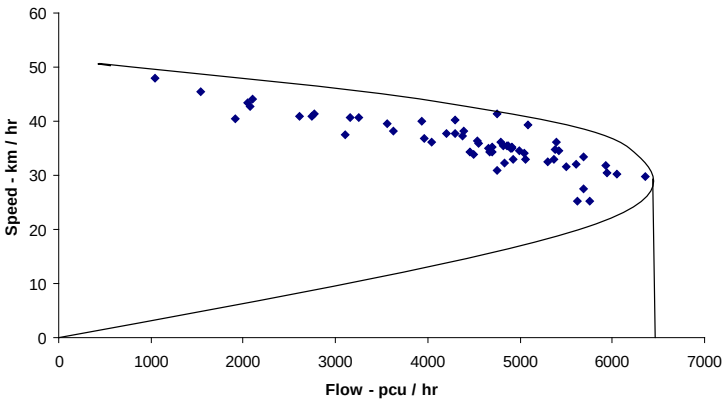

Figure 8 : Speed Flow Curve – Arcot Road

Figure 9. Speed Flow Curve – Medavakam Tank Road

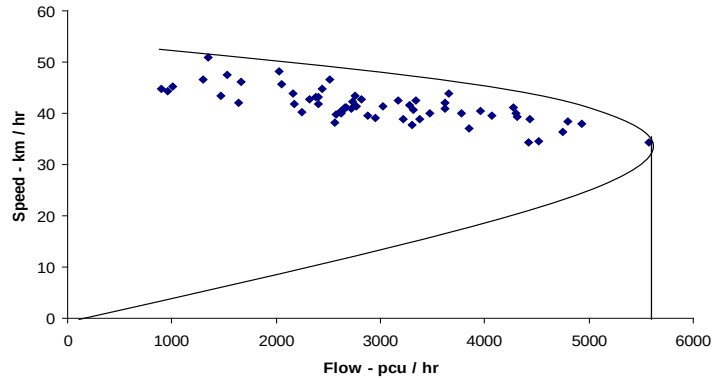

Figure 9 : Speed Flow Curve – Medavakam Tank Road

Figure 10. Speed Flow Curve – Periyar Road

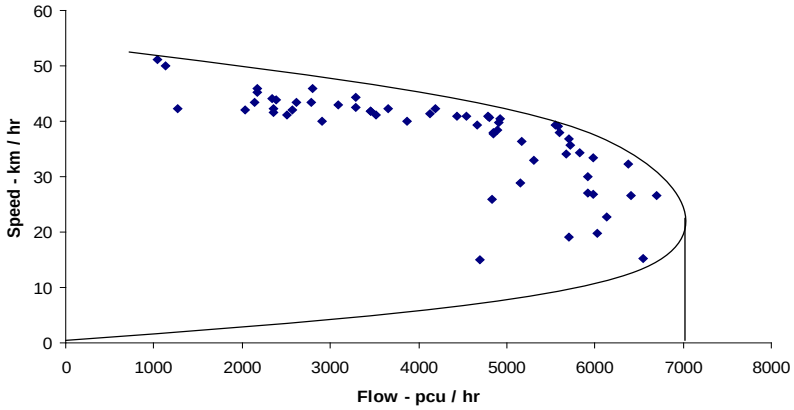

Figure 10 : Speed Flow Curve – Periyar Road

Figure 11. Speed Flow Curve - Manarsami Koil Road

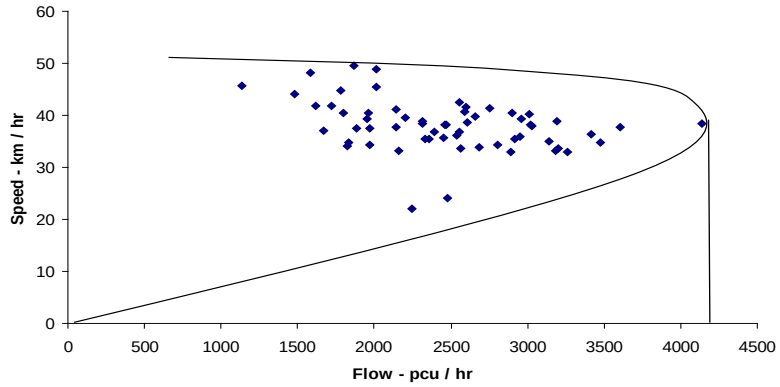

Figure 11 : Speed Flow Curve – Manarsam I Koll Road

Figure 12. Speed Flow Curve - North Beach Road

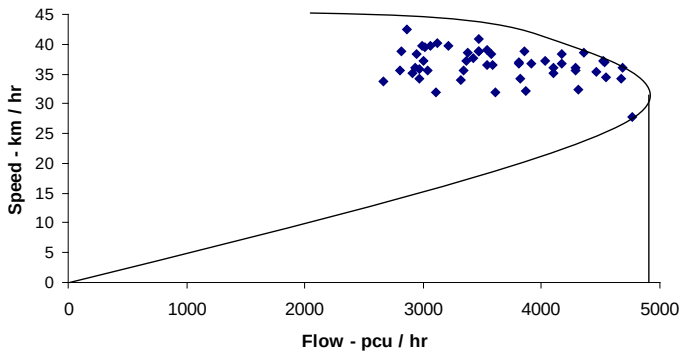

Figure 12 : Speed Flow Curve – North Beach Road

VIII. Observations and Conclusions

It is clear from literature that Capacity of a facility is only an estimate and is not a constant. It varies with time, location, composition and other local factors. The major elements of traffic flow are the Vehicle, Driver and Way. Since the roads in India are not of standard dimensions and there is lack of lane discipline with several types of vehicles sharing the same way, it would be appropriate to adopt direct empirical methods for capacity estimation. With various factors influencing the value of capacity, the Direct empirical methods using the observed fundamental traffic characteristics like Headway (inter arrival time), volume and speed are relevant for capacity estimation.

The distribution of Headway (inter arrival time) of vehicles were found to vary from location to location. However, when three best distributions were considered, Log Normal 2, Inverse Gauss and Exponential distributions were found to represent the traffic data. The average capacity estimated by this method was found to be 5649 PCU.

The estimated capacity by the Selected Maxima method with a time slice of 5 minutes was 5336 PCU. However when three maximum flows in each 5 minute interval were taken into consideration, the average capacity was estimated as 5075 PCU. There is a drop of nearly five per cent in capacity when the time interval was increased from 5 to 15 minutes.

Even though the pattern of the speed flow curve is parabolic in nature, the data obtained from the field were found to be scattered. Using the enveloping curve technique, the average capacity flow for a two-lane two-way mid-block was estimated as 5146 PCU.

As reported in literature, the capacity estimate made using the headway model was observed to be the highest. Since the fundamental diagram approach has the speed factor also in the capacity estimation, this method will indicate the capacity flow with the known stream speed. As the fundamental parameters of traffic flow are headway, volume and speed, it is felt that for capacity estimation, all the three methods need to be done and compared for arriving at the best value.

The estimated capacity value by all the three methods was found to be much higher than the IRC recommended value for two-lane two-way divided urban roads. The reason for the higher capacity value could be attributed to the drastic change in the flow characteristics and the driver behaviour. The higher volume on the road has made the drivers to be more aggressive. The lateral and longitudinal gaps between vehicles on the urban roads are also lesser now, than the recommended values. The recommended PCE values of IRC, especially for autorickshaws (2 – for more than 10% of the total traffic) and for motorized two wheelers (0.75 – for more than 10% of the total traffic) appear to be on the higher side. Vehicles are also observed to traverse with reduced headway and side clearances because of the increase in vehicular volume. Even though several attempts have been made to estimate the Passenger Car Unit (PCU) value for various categories of vehicles, there are no acceptable values for a given condition and it requires further research.

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Trace Elements Distribution in Soil Columns as Affected by Cassava Effluents Application

By Babajide, N. A. Aremu, D. O., Akinyele, O. A., Oladimeji, S. T. & Ogunlade, C. A.

University of Ibadan, Nigeria

Abstract- Cassava effluent in form of wastewater obtained during the processing of "garri", is indiscriminately released into the environment, the effect of which is not fully known on soils and groundwater. This study investigated the distribution of two trace elements (Cu and Mn) found in the effluent through soil columns. The experiment was conducted using three different soil types namely; Iwo, Apomu and Egbeda and four varying proportions of cassava effluent (0ml – Control, 6ml, 12ml and 18ml). The four varying proportions of the effluents translates to 2.74, 5.48, 8.22, 10.96 mg/l of Cu and 1.83, 3.66, 5.49, 7.32 mg/l of Mn. The soil samples were compacted to soil bulk density of 1.50g/cm3 inside 50 cm long and 15cm diameter columns. The leachates were collected every 24 hours after the start of the experiment and analyzed for Cu and Mn using the Atomic Absorption Spectrophotometer (AAS). The result shows that the total leachate concentration (in mg/l) of Cu in 7days varied from 5.54 to 10.11 for Iwo, 5.13 to 14.81 for Apomu and 9.2 to 15.31 for Egbeda as cassava effluent volume increased from 0ml to 18ml; for Mn, it varies from 0.81 to 27.93, 1.7 to 34.26 and 12.03 to 36.19 for Iwo, Apomu and Egbeda respectively. The effect of increasing cassava effluent volume on leachate concentration for both Cu and Mn was in the order: Apomu > Egbeda > Iwo. The difference in total volume (in ml) leached after 40 minutes of simulated rainfall for 0ml and 12ml effluent additions were 13.3, 10.3 and 2.2 for Iwo, Apomu and Egbeda respectively.

Keywords: soil type (iwo, apomu, egbeda), cassava effluents, trace elements (copper, manganese) and leachate.

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Strictly as per the compliance and regulations of :

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I. Introduction

Cassava (*manihot esculenta crantz),* the major and the chief staple food in tropical Africa, is regarded as the most important among root and tuber crops. It can be processed into several products such as *gaari, fufu*, starch, flour, etc. It is the processing of those products that releases the waste water to the immediate environment and little effort is made to channel and collect the effluent for proper disposal. Cassava is one of the ancient foods that have helped to improve the rural life by reducing the nation's poverty rate and also serves as means of wealth generation. As the demand for cassava increases, so the amount of the waste water released into the environment increases which cause environmental pollution. Cassava consist of 60-70% water, processing it dry reduces the moisture content and convert it into a more durable and stable product with less volume, which makes it more transportable. Cassava, a plant originated from North-East Brazil, with the root as a good source of carbohydrate and the leaves provide an inexpensive and rich source of protein and minerals in the human diet (Adewusi and Akindahunsi, 1994). It is a traditional crop used by low-income people in the tropics and recommended for both consumption and starch production.

Soils are crucial to life on earth because to a large extent, the soil quality determines the nature of plant ecosystems and the capacity of land to support animal life and society (Brady and Weil, 1999). As human societies become increasingly urbanized, fewer people have inmate contact with the soil and individuals tend to lose sight of many ways in which depend on soils for their prosperity and survival. Therefore the rate to which man depend on the soil is likely to increase not decrease in the future. Of course, soils will continue to supply us with nearly all our food and much of our fibre, large percentage of our medicines and also biomass grown on soils which is likely to become an increasingly important source of energy and industrial feed stocks.

Cassava, which is processed into different products, has gone through various processes which include; peeling, washing, grating, dewatering, pulverizing and frying. The effluents are removed during the process of dewatering by applying pressure on the grated cassava mash using wood, stones, screw or hydraulic press and this process of pressing takes about 2-5 days. The waste water released during the processing, infiltrates into the soil as contaminant or pollutant, which produce various intermediate and final chemical products that can be environmentally damaging under normal physiological condition.

According to Brady and Weil (1999), the effluent infiltrating the soil is greatly influenced by the predominant type of soil due to the varying infiltration capacities of different soils which depends on the size and shape of grains. As part of these effluents infiltrate into the soil, the remaining parts that are left on the soil surface are easily washed away by run-off from heavy rainfall into a nearly stream or pond. These effluents contain cyanide in the form of hydrogen cyanide (HCN) which is very toxic to human life. The presence of

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hydrogen cyanide in cassava was established by Carmody and Francis (1979). The extent of damage to which waste water that infiltrates into the soil is imposing on the soil environment has not been properly quantified. The presence of this solute in the soil may affect the soil water quality and the chemical property of the soil both on long term and short term bases. The fate and the transport of these waste water constituents in the soil depend on various factors. The factors include the adsorption characteristics of the constituents to the soil particles; organic matter content of the soil; the soil solution pH and the loading rate of the constituent (Osunbitan, 2007).

Several developments over time have proved that there has been no much interest in the effects that cassava effluents can cause to the immediate environment. The major reason being that, most of the cassava products that release these effluents are being processed in the rural areas. The introduction of toxic and harmful waste into the environment will have adverse effect on human and animal life, agricultural productivity, soil and even the natural ecosystems. It is important then to know the distribution of these trace elements in the soil so as to mitigate the harmful effects they may have on the soil and/or groundwater environment. Thus, the objectives of this study are to evaluate the vertical distribution of trace elements from cassava waste water in the soil column and to determine the effects of the waste water on the flow rate of water through the soil column.

II. Materials and Method

The experiment was conducted using three different types of soils classified as *Iwo, Apomu and Egbeda* series. The three soils were collected from the Obafemi Awolowo University Teaching and Research Farm to the depth of 40 cm at 8 cm depth interval. The sites at which the samples were collected have no history of heavy metal application which could have occurred through fungicide, fertilizer or sewage effluent application. The soil samples were collected using shovels and packed into sacks and then transported to the laboratory for the column leaching experiment. Twelve 50 cm long and 15 cm diameter PVC pipes held the samples, four for each soil type.

Iwo series are geographically classified as *Iwo association*, soils derived from coarse-grained granites, coarse-grained granitic gneisses and pegmatite and form the most extensive group of soils in Western Nigeria, and taxonomically classified as *Ibadan fasc*. Soils of these series usually occupy level or gently sloping sites at high or intermediate levels in the topography. The sand fraction is usually coarse and small fragments of feldspar are often present. Furthermore, a presence of relatively un-weathered minerals at moderate depth suggests an ample reservoir of nutrients for deep rooted plants (Smith and Montgomery, 1962).

Apomu series are geographically classified as *Apomu association* and taxonomically classified as *Apomu fasc*. By definition, profiles of Apomu series are very sandy in texture to a depth of at least 50 cm and are free of stones and concretions to a similar depth. On account of the sandy nature of the soil, this soil has poor properties of moisture and nutrient retention and is considered unsuitable for cocoa, coffee, kola and citrus (Smith and Montgomery, 1962).

Egbeda series are geographically classified as *Egbeda association*, soils derived from fine-grained biotite gneisses and schists, and taxonomically classified as *Egbeda fasc*. By definition, they are clayey in texture, which is not sandier than very clayey sand in horizons between 25.4 cm and 30.5 cm from the surface. The sand fraction is usually very fine throughout the profile, but a well-marked gravel layer, including quartz gravel, quartz stones and fairly frequent small and spherical ironstone concretions, is present between depths of 25.4 cm and 50.8 cm. The mottled clays usually descend to depths greatly in excess of 305 cm and the only change normally displayed with depth is in the intensity and colouring of the mottling (Smith and Montgomery, 1962).

The effluent was collected as its being released when grated cassava mesh are placed under a screw press during garri production.

a) Method

The soil samples were collected and sun-dried to a moisture content of about 6% after which the soils were pulverised to remove plant stems and roots and then homogenized by sieving of the clumps and gravel using 2 mm sieves. Soil columns were then prepared using the collected soils for the mobility experiment. The PVC pipes mentioned earlier open at both ends were used. Twelve columns were packed with the dried soils to a bulk density of 1.50 g/cm^3 - four columns for each soil type. This required that about 10 kg (*mass, m = density, ρ × volume, v*) be packed into the column volume by volume (interval wise) for everything to fit in uniformly.

The experimental design is 3 × 4 factorial arrangement. The factors considered are soil type (Iwo, Egbeda, and Apomu soils) and cassava effluents volume of application (0 ml – for control experiment, 6 ml, 12 ml, and 18 ml). The cassava effluent application translates to: 2.74, 5.48, 8.22, 10.96 mg/l of copper; and 1.83, 3.66, 5.49, 7.32 mg/l of manganese for 0 ml, 6 ml, 12 ml, and 18 ml respectively. Table 3.1 shows the treatments chosen and their levels of application as used in this experiment.

The effluent samples were metered linearly into the saturated soil columns from the top and allowed to leach through the soil columns. Four volumes (0 ml, 6

ml, 12 ml, and 18 ml) were employed for the four columns with each soil type respectively. A funnel and a plastic beaker placed at the end of each column were used to collect leaching fluids from the columns as shown in Fig. 3.1. Rainfall was then simulated to model solute transport through the soil column. The leached samples through each of the columns were chilled immediately after collection until when required for analysis. The samples were later taken to the Central Science Laboratory, Obafemi Awolowo University, Ile-Ife for determination of Cu and Mn content using the Atomic Adsorption Spectrophotometer (AAS).

Table 1 : Treatment and Levels of Application

Experimental run	Soil types	Volume of Cassava Effluents (ml)
1	Iwo	0
2	Iwo	6
3	Iwo	12
4	Iwo	18
5	Apomu	0
6	Apomu	6
7	Apomu	12
8	Apomu	18
9	Egbeda	0
10	Egbeda	6
11	Egbeda	12
12	Egbeda	18

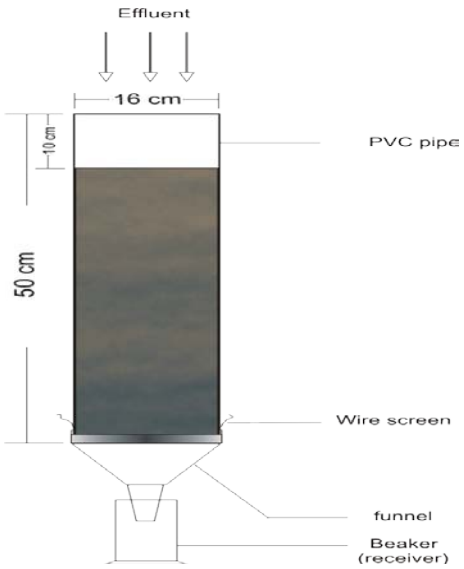

Fig. 1 : Soil column set-up with receiver in place

III. Results and Discussion

a) Leachate Analysis

The results obtained from the experiment are hereby presented. These were determined by the use of the Atomic Adsorption Spectrophotometer (AAS).

i. *Copper*

The concentration of copper in the leachate through the soil columns for seven days of the experimental run are given in Table 2. Figure 2 shows the daily leachate concentrations. There is an increase in total concentration leached – obtained by adding the daily leachate concentrations – with increasing effluent volume for Apomu and Egbeda soils while it remains unclear for Iwo soil. After about five days, the ions had almost completely leached in the Apomu soil. Iwo and Egbeda soils follow similar patterns and were not leached-out in the Seven days of the experiment.

ii. *Manganese*

Table 3 shows the prevalence of manganese, Mn, in the collected samples. It shows an increase in total concentration leached with increasing effluent volume for Apomu and the relationship between the total concentration leached and effluent volume remains indeterminate for the Iwo and Egbeda soils. Figure 3 shows the daily leachate concentrations for the three soil types. Apomu quickly dissipates much of the ions reaching a peak concentration on Day 3 or Day 4.

Table 2 : Concentration (in mg/l) of Cu in the leachate

Soil Type	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Total
				0 ml of effluents				
Iwo series	0	3.04	0.14	1.65	0	0.71	0	5.54
Apomu series	2.11	0.69	1.61	0	0.72	0	0	5.13
Egbeda series	0	2.14	0	4.81	0	0	2.67	9.2
				6 ml of effluents				
Iwo series	0.4	0	1.54	3.31	1.74	2.16	0.89	10.04
Apomu series	1.24	1.89	1.43	1.95	0	0	1	7.51
Egbeda series	0	0.83	2.78	2.91	2.05	1.17	0	9.74
				12 ml of effluents				
Iwo series	1.85	2.08	0	1.98	0	1.85	2.35	10.11
Apomu series	0	2.17	1.7	3.56	0	0	2.43	9.86
Egbeda series	0	2.74	0.54	1.4	3.06	1.7	2.32	11.76
				18 ml of effluents				
Iwo series	1.56	0	1.48	1.18	0	1.94	2.1	8.26
Apomu series	0	3.23	4.44	3.05	3.12	0.97	0	14.81
Egbeda series	1.71	0	4.57	0.66	3.86	2.49	2.11	15.31

Table 3 : Concentration (in mg/l) of Mn in the leachate

Soil Type	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Total
				0ml of effluents				
Iwo series	0	0	0.37	0	0.44	0	0	0.81
Apomu series	0.3	0.24	0.06	0	0.36	0.74	0	1.7
Egbeda series	0	0.09	0.08	11.2	0	0.62	0.04	12.03
				6ml of effluents				
Iwo series	0.83	0.27	0	2.45	3.46	2.01	0.31	9.33
Apomu series	0.41	4.21	1.04	6.33	0.35	0	0	12.34
Egbeda series	0.53	0.91	7.38	2.4	0.85	1.74	0.74	14.55
				12ml of effluents				
Iwo series	0.25	0	0	0.34	0	1.24	1.12	2.95
Apomu series	1.23	1.14	6.27	6.12	2.93	1.47	0.29	19.45
Egbeda series	0	0	2.14	1.31	3.3	2.07	2.12	10.94
				18ml of effluents				
Iwo series	1.47	1.97	7.51	0.99	0.72	8.93	5.77	27.93
Apomu series	0	4.12	11.2	8.29	8.63	2.02	0	34.26
Egbeda series	0.24	2.97	6.46	0	10.42	7.48	8.62	36.19

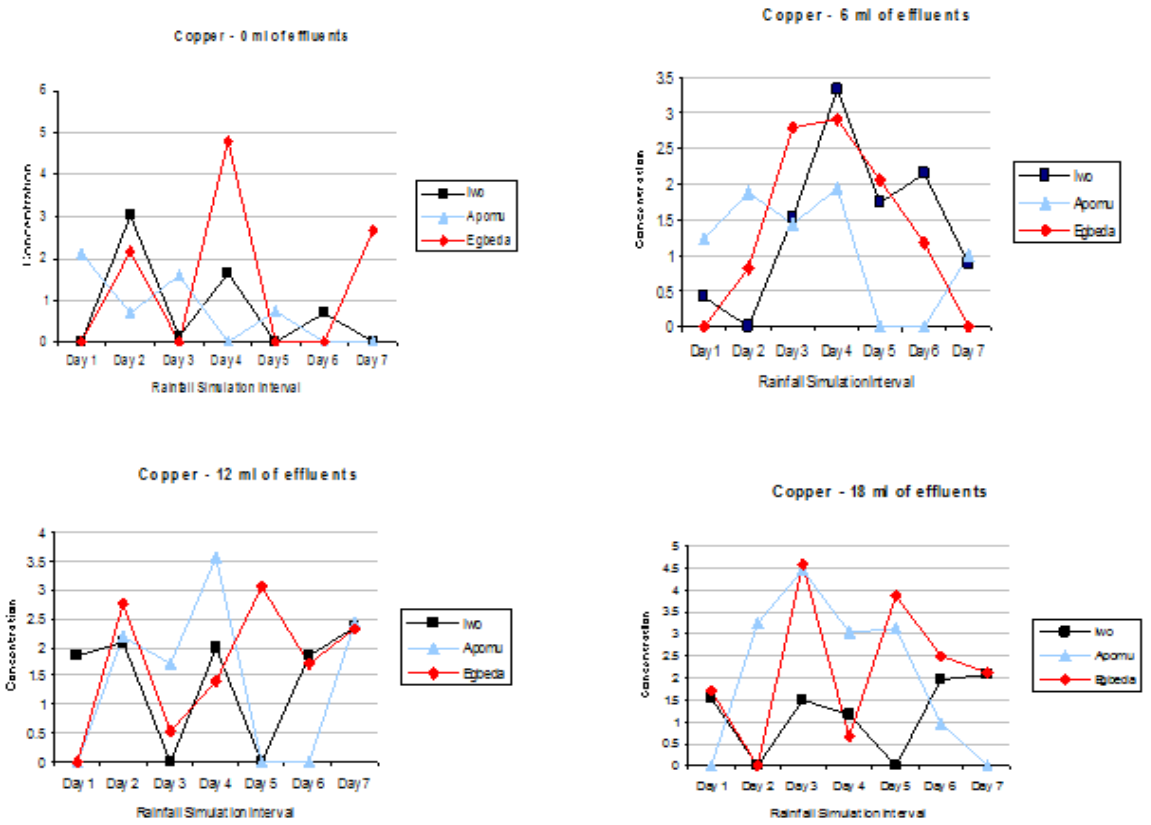

Figure 2 : Concentrations (in mg/l) of Copper with Rainfall Simulation Interval for different soil types

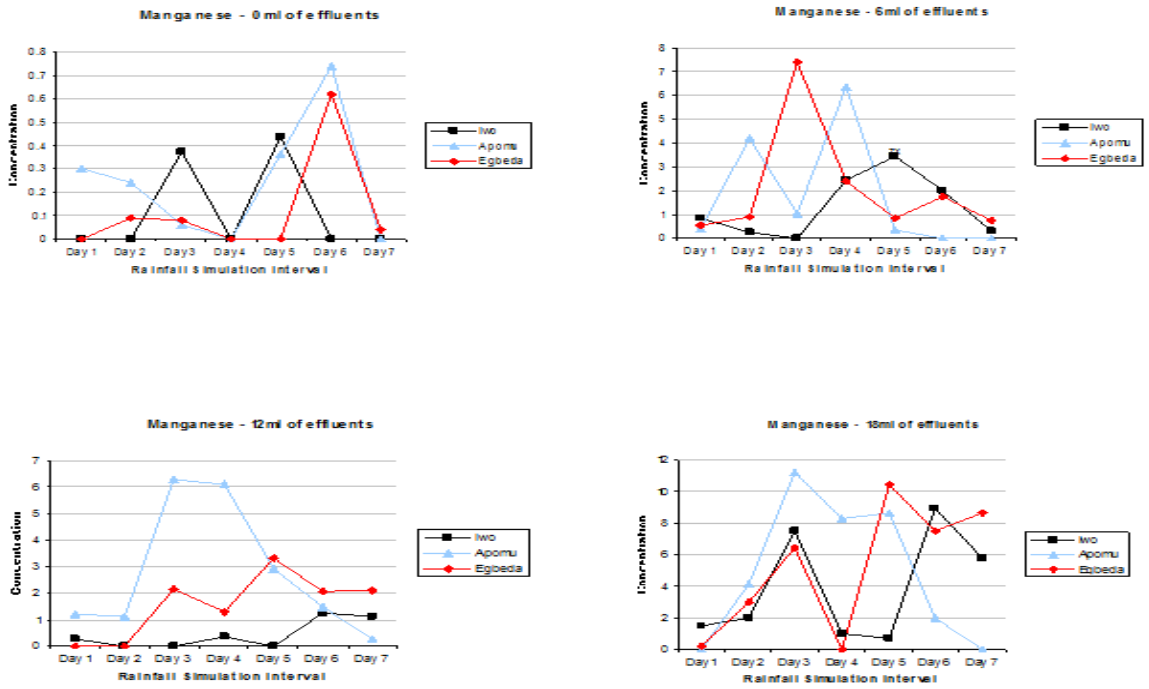

Figure 3 : Concentrations (in Mg/l) of Manganese with Rainfall Simulation Interval for different soil types

b) Effects of Varying Proportions of Effluents

The effect of varying concentration 0, 6, 12, 18 ml of effluent on the mobility of Cu and Mn through the soil columns is shown in Figure 4 and Figure 5 respectively.

The results for the three soils indicate the presence of Cu and Mn in the original soils without effluent addition. Increasing the concentration of Manganese leads to a corresponding increase in leachate concentration for Apomu soil. For Iwo soil, and more importantly for Egbeda soils, the structure (prominence of the soil micro- and macro- pores) and chemistry have a marked effect on the rate of leaching of Mn through the soil. The inability to convincingly determine the pattern for Iwo must be due primarily to its organic nature, and then to clayey proportion. The presence of soil micro-pores is the primary factor influencing flow through Egbeda soil.

c) Rate Analysis

When compared with the control experiment (Figure 6) and Figure 7 (Rate analysis for 12 ml effluent addition) shows that in soil columns to which the cassava effluent was added, the rate of infiltration by the simulated rainfall dropped for Iwo and Apomu soils and rose for the Egbeda soil. The effluent addition also caused the flow to reach its peak earlier than in the Control experiment. This is explained by the fact that due to the slightly starchy nature of the effluent, most the soil macro-pores must have been blocked which leads to a lower flow rate normally. However, the Egbeda soil having more micro-pores which are not blocked by the effluent quickly reaches its peak flow earlier than Iwo and the Apomu soils – a reversal of what occurs in the Control experiment.

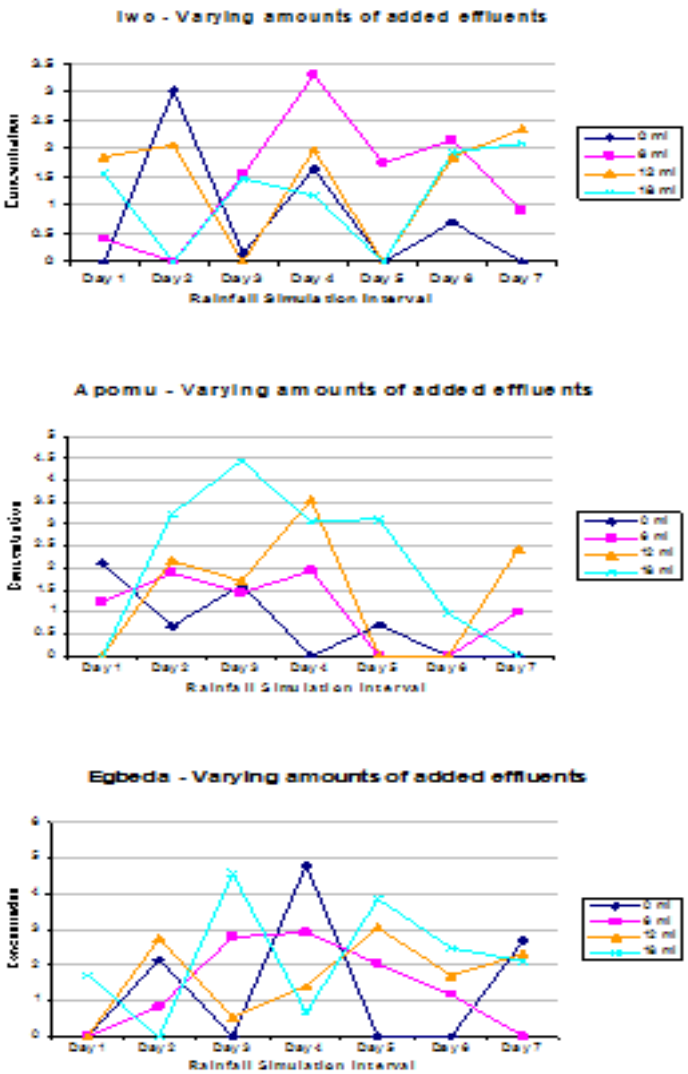

Figure 4 : Copper concentrations (mg/l) with Rainfall Simulation Interval for varying effluent proportions

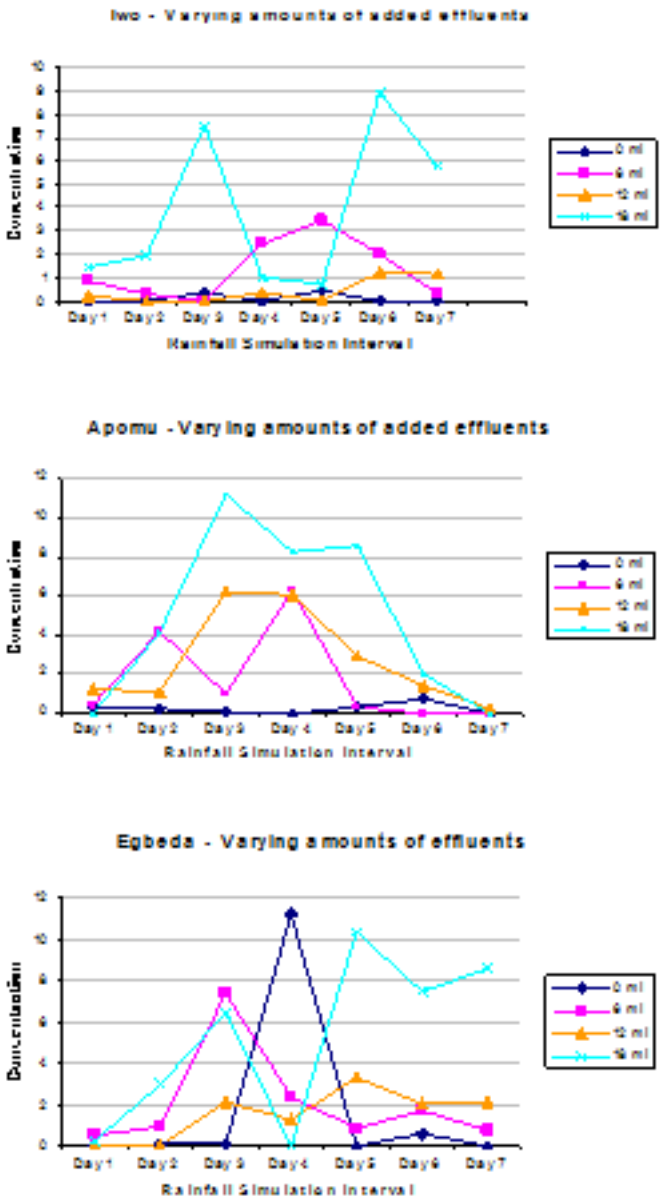

Figure 5 : Manganese concentrations with Rainfall Simulation Interval for varying effluent proportions

Table 4 : Rate of flow through soil columns

Duration (min)	Iwo (0ml)	Iwo (12ml)	Apomu (0ml)	Apomu (12ml)	Egbeda (0ml)	Egbeda (12ml)
2	20	21	52	43	24	34
4	51	40	81	75	40	64
6	51	46	82	77	64	107
8	44	40	75	69	71	74
10	38	34	50	50	64	48
12	33	36	35	34	45	28
14	27	30	27	24	30	22
16	23	22	22	18	23	16.5
18	20	19	18	14	19	13

20	18	16	13.6	13.6	15	11
22	16	14	10.6	13.9	13	9.4
24	14	12.5	8.6	12.8	11	7.8
26	11	11	6.8	10.8	9.4	6.8
28	10.6	9.8	5.6	9	8	6
30	9	10.4	4.6	8	7.6	5.5
32	8.5	9.8	3.9	7	6.8	5.1
34	7.3	9.4	3.4	6.2	6	4.6
36	6.5	9	3	4.6	5.6	4.4
38	5.8	8	2.7	3.6	5.1	4
40	5.1	7.6	2.4	3.4	4.8	3.4
Total volume leached	418.8	405.5	507.2	496.9	472.3	474.5

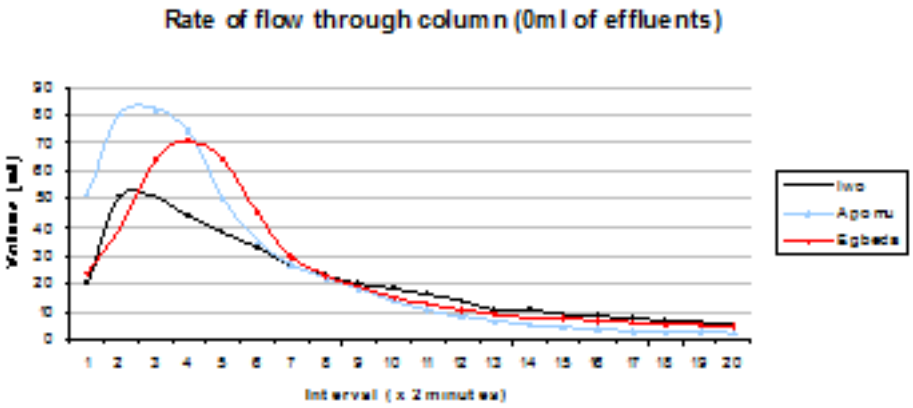

Figure 6 : Rate of flow for 0ml effluent addition (control experiment)

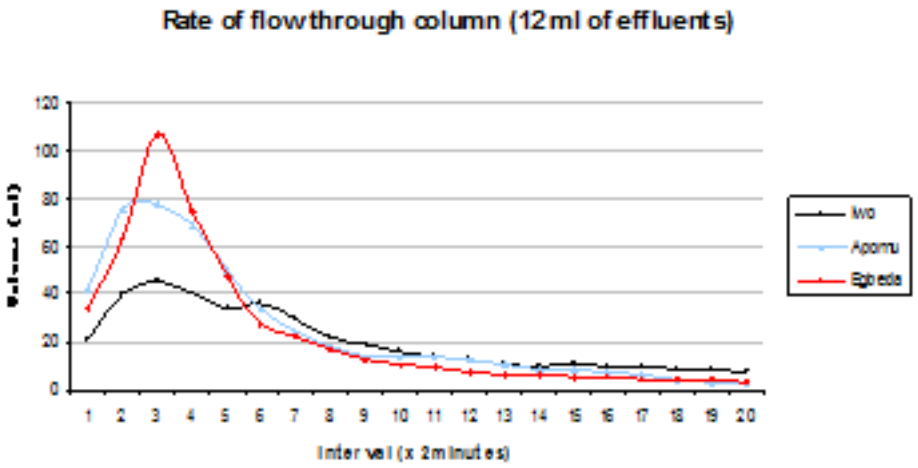

Figure 7 : Rate of flow for 12ml effluent addition.

IV. Conclusion

This experiment shows that distribution of heavy metals through soils is enhanced by porosity, and the organic content of the soil. Highly porous soils like Apomu displayed an unusually high mobility of these two ions under consideration. The more organic Iwo and clayey Egbeda displayed similar transport characteristics. At the end of the duration chosen for the experiment, leachate from the Apomu soil columns had no trace of the metals introduced. The effect of soil micro-structure and organic content is clearly evident and as observed serve as the key factors influencing the mobility of Copper, Cu, and Manganese, Mn, through the soils types studied. It has been shown by this experiment that these two metals will flow through the geological topsoil - surface to 40 cm depth - to lower layers and the rate decreases from Apomu to Iwo to Egbeda.

Thus, areas where cassava is being indiscriminately processed without any regard for wastewater treatment, with the Apomu soil type, will be at high risk of underground water contamination. For the Iwo and Egbeda soil types, it is observed that mobility was lesser than as it was for Apomu. The fairly average concentration was being released everyday and at the end of the seven day run, the concentration had hardly reduced. This implies that in such areas, with Iwo and Egbeda soil types, crops are at a higher exposure to re-absorption.

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Reflection and Transmission of Elastic Waves at a Loosely Bonded Interface between an Elastic Solid and a Viscoelastic Porous Solid Saturated by Viscous Liquid

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Abstract- In the present paper, a problem on reflection and transmission of elastic waves at a loosely bonded interface between an elastic solid and a viscoelastic porous solid saturated by viscous liquid is studied. The study is carried out with the assumption that the interface behaves like a dislocation which preserves the continuity of stress and allows a finite amount of slip. The appropriate potential functions for reflected and transmitted waves satisfy the required boundary conditions at the interface. The relations between amplitude ratios of different reflected and refracted waves are obtained for incidence of P and SV waves. The amplitude ratios of various reflected and refracted waves are computed for a particular model. The effects of loosely boundary and viscoelasticity are observed on these amplitude ratios.

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Baljeet Singh [α] & Surjeet Singh [σ]

Abstract- In the present paper, a problem on reflection and transmission of elastic waves at a loosely bonded interface between an elastic solid and a viscoelastic porous solid saturated by viscous liquid is studied. The study is carried out with the assumption that the interface behaves like a dislocation which preserves the continuity of stress and allows a finite amount of slip. The appropriate potential functions for reflected and transmitted waves satisfy the required boundary conditions at the interface. The relations between amplitude ratios of different reflected and refracted waves are obtained for incidence of P and SV waves. The amplitude ratios of various reflected and refracted waves are computed for a particular model. The effects of loosely boundary and viscoelasticity are observed on these amplitude ratios.

I. Introduction

The observed attenuation of the seismic wave in the earth helps in getting information regarding the composition and state of deep interior. This attenuation cannot be explained by assuming the earth to be an elastic solid. Biot (1956a) studied the propagation of the plane harmonic seismic waves in liquid saturated porous solids. Biot (1962) presented a unified treatment of the mechanics of deformation and acoustic propagation in porous media, where liquid-solid medium is treated as a complex physico-chemical system with resultant relaxation and viscoelastic properties. Deresiewicz (1960) and Deresiewicz and Rice (1962) studied the reflection at the plane traction-free surface of non-dissipative and dissipative liquid saturated porous solids respectively. They considered the porous solid as perfectly elastic with no internal energy loss.

Viscoelasticity is an important property of many rocks in the crust, which is a major cause of seismic attenuation. In the presence of porosity, a viscoelastic solid permeated by pores and fractures and saturated with viscous fluid becomes a more realistic model for sedimentary or reservoir rocks. Biot (1956b) established the equations for the deformation of a viscoelastic porous solid containing a viscous fluid under the most general assumptions of anisotropy. Sharma and Gogna (1991) studied the seismic wave propagation in a viscoelastic porous solid saturated by viscous liquid. Vashishth et al. (1991) investigated a problem on reflection and transmission of a plane periodic wave incident on the loosely bonded interface between an elastic solid and a liquid-filled porous solid with the assumption that the interface behaves like a dislocation which preserves the continuity of stress allowing a finite amount of slip. Vashishth and Gogna (1993) studied a problem of reflection and refraction of plane seismic waves incident on an interface of two loosely bonded half-spaces, an elastic solid half-space and a liquid-saturated porous solid half-space, which permits a finite amount of slip. Vashishth and Sharma (2008) discussed the wave propagation in a medium considered as a viscoelastic, anisotropic and porous solid frame such that its pores of anisotropic permeability are filled with a viscous fluid. Recently, Sharma (2012) studied the propagation of Rayleigh waves on the stress-free surface of a viscoelastic, porous solid saturated with viscous fluid.

In the present paper, a problem is considered on reflection and transmission of elastic waves on loosely bonded interface between an elastic solid and a viscoelastic porous solid saturated by viscous liquid. For incidence of P and SV waves, the amplitude ratios of various reflected and refracted waves are computed for a particular model. The effects of loosely boundary and viscoelasticity are shown graphically on these amplitude ratios.

II. Basic Assumptions

Murty (1976) introduced a real bonding parameter to which numerical values can be assigned corresponding to a given degree of bonding between half-spaces and discussed the particular cases of ideally smooth and fully bonded interfaces corresponding to the values 0 and ∞ of the bonding parameter. He considered three basic assumptions. The first assumption is that the stresses are continuous

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across the interface. The second assumption is that the microscopic structure of the material at the interface is such that a finite amount of slip can take place at the interface when a periodic wave is propagating. The third assumption is that there exists a linear relation between slip and shear stress at the interface which implies that different degrees of bonding correspond to different values of the constant of proportionality. The principle behind the third assumption is that there must exist some relation between the local shearing stress and the 'slip' at the interface such that when the shearing stress is zero, the 'slip' is infinite implying that the interface behaves like an ideally smooth interface and when the 'slip' vanishes the interface behaves as a fully bonded interface. We may assume that shearing stress = $K \times$ slip at the interface of loosely bonded media so that the vanishing of K corresponds to an ideally smooth interface and an infinitely large value of K corresponds to a welded interface. The intermediate values of K represent a loosely bonded interface.

We assume a model having a viscous liquid layer between the elastic half-space and liquid-saturated porous viscoelastic solid half-space. Let H be the thickness of the layer and ξ be the coefficient of viscosity and $H \to 0$ implying that the thickness of the layer is infinitely small. It is reasonable to assume that the shearing stress at the interface is given by

$$\sigma_{xz} = \xi\left(\frac{\partial \dot{u}}{\partial z}\right), \tag{1}$$

where $\dot{u}$ is the component of velocity parallel to the interface (dot represents time derivative) and the partial derivative is taken normal to the interface. Equation (1) can be approximated as

$$\sigma_{xz} = \frac{\xi}{H}(\dot{u} - \dot{u}_e), \tag{2}$$

where $(\dot{u} - \dot{u}_e)$ is the jump in the x-component of velocity across the layer. If we assume the waves to be time harmonic, then equation (2) can be written as

$$\sigma_{xz} = -i\omega\left(\frac{\xi}{H}\right)(u - u_e), \tag{3}$$

where ω is the angular frequency and u and u_e are the displacement components parallel to the interface at the boundaries of the infinitesimal thin layer of viscous liquid.

III. Basic Equations

According to Biot (1962), the differential equations governing the displacement $\vec{u}$ of solid matrix and $\vec{U}$ of interstitial liquid in a homogeneous isotropic porous solid saturated by viscous liquid are

$$\mu\nabla^2\vec{u} + \left(\lambda + \mu + \alpha^2 M\right)\nabla\left(\nabla.\vec{u}\right) + \alpha M\,\nabla\left(\nabla.\vec{w}\right) = \frac{\partial^2}{\partial t^2}\left(\rho\vec{u} + \rho_f\vec{w}\right), \tag{4}$$

$$\nabla\left[\alpha M\left(\nabla.\vec{u}\right) + M\left(\nabla.\vec{w}\right)\right] = \frac{\partial^2}{\partial t^2}\left(\rho_f\vec{u} + m\vec{w}\right) + \frac{\eta}{\chi}\frac{\partial\vec{w}}{\partial t}, \tag{5}$$

Where, the vector $\vec{w} = \beta\left(\vec{U} - \vec{u}\right)$ represents the flow of liquid relative to the solid measured in terms of volume per unit area of the bulk medium, λ, μ are Lame's constants for the solid, ρ is mass density of the bulk material, ρ_f is mass density of liquid, m is Biot's parameter which depends upon porosity β and ρ_f, η is pore fluid viscosity, and χ is permeability. α and M are the elastic coefficients related to the coefficient of fluid content γ, unjacketed compressibility δ and jacketed incompressibility $K\left(=\lambda + \frac{2}{3}\mu\right)$ by $\alpha = 1 - \delta K$, $M = 1/\left(\gamma + \delta - \delta^2 K\right)$.

The stresses τ_{ij} and liquid pressure p_f are given by solid

$$\tau_{ij} = 2\mu e_{ij} + \left[\left(\lambda + \alpha^2 M\right)e + \alpha M\xi\right]\delta_{ij},\ p_f = \alpha M_e - M\xi, \tag{6}$$

Where $e_{ij} = \frac{1}{2}(u_{i,j} + u_{j,i})$ is strain tensor and $e = div\ \vec{u}$, $\xi = div\,\vec{w}$ are the dilatations. The viscoelastic and relaxation properties are obtained by replacing the elastic coefficients λ, μ, γ and δ by the operators λ^*, μ^*, γ^* and δ^* respectively. Applying the correspondence principle, we have

$$K^* = \lambda^* + \frac{2}{3}\mu^*,\ \alpha^* = 1 - \delta^* K^*,\ M^* = 1/\left(\gamma^* + \delta^* - \delta^{*2}K^*\right) \tag{7}$$

and, the stress-strain relations are

$$\tau_{ij} = 2\mu^* e_{ij} + \left[\left(\lambda^* + \alpha^{*2} M^*\right) e + \alpha^* M^* \xi\right]\delta_{ij}, \; p_f = -\alpha^* M^* e - M^* \xi, \tag{8}$$

With the help of (7), the equations of motion (4) and (5) become

$$\mu^* \nabla^2 \vec{u} + \left(\lambda^* + \mu^* + \alpha^{*2} M^*\right)\nabla e + \alpha^* M^* \nabla \xi = \frac{\partial^2}{\partial t^2}\left(\rho \vec{u} + \rho_f \vec{w}\right), \tag{9}$$

$$\nabla\left(\alpha^* M^* e + M^* \xi\right) = \frac{\partial^2}{\partial t^2}\left(\rho_f \vec{u} + m\vec{w}\right) + \frac{\eta}{\chi}\frac{\partial \vec{w}}{\partial t}, \tag{10}$$

Following Sharma and Gogna (1991), in an unbounded viscoelastic porous solid saturated by viscous liquid, two dilatational waves of first and second kinds (P_1 wave and P_{11} wave) and one shear wave propagate. They also obtained the velocities $v_j, \; (j = 1,2)$ of dilatational waves and the velocity v_3 of shear wave as

$$v_j^2 = \frac{\lambda^* + 2\mu^*}{\rho_j^*}, \; (j = 1,2)\, v_3^2 = \frac{\mu^*}{\rho_3^*}. \tag{11}$$

To consider only two-dimensional reflection problem, we shall restrict the plane wave solutions for the displacement potentials to those that have propagation and attenuation vectors in the x-z plane. Following Sharma and Gogna (1991), the components of displacement vectors are taken as

$$\vec{u} = (u, 0, w), \; \vec{\omega} = (U, 0, W), \; \vec{u}_e = (u_e, 0, w_e), \tag{12}$$

where

$$u = \frac{\partial \phi_{11}}{\partial x} + \frac{\partial \phi_{12}}{\partial x} + \frac{\partial \psi}{\partial z}, \; w = \frac{\partial \phi_{11}}{\partial z} + \frac{\partial \phi_{12}}{\partial z} - \frac{\partial \psi}{\partial x}, \; \psi = \left(-\vec{\psi}_1\right),$$

$$U = \mu_1 \frac{\partial \phi_{11}}{\partial x} + \mu_2 \frac{\partial \phi_{12}}{\partial x} + \alpha_0 \frac{\partial \psi}{\partial z}, \; W = \mu_1 \frac{\partial \phi_{11}}{\partial z} + \mu_2 \frac{d\phi_{12}}{\partial z} - \alpha_0 \frac{\partial \psi}{\partial x},$$

$$u_e = \frac{\partial \phi_e}{\partial x} + \frac{\partial \psi_e}{\partial z}, \; w_e = \frac{\partial \phi_e}{\partial z} - \frac{\partial \psi_e}{\partial x}, \; \psi_e = \left(-\vec{\psi}_e\right),$$

$$\mu_j = \frac{\rho_f \alpha^* - \rho + \left(\lambda^* + 2\mu^*\right)/v_j^2}{\rho_f - \left(m + i\frac{\eta}{\omega\chi}\right)\alpha^*}, \; (j = 1,2), \; \alpha_0 = -\frac{\rho_f}{\left(m + i\eta/\omega\chi\right)}.$$

IV. Reflection and Transmission

For incidence of *P* or *SV* wave, there will be reflected *P*, SV waves in elastic half-space and refracted P_1, P_{11} and SV waves in viscoelastic porous solid as shown in Figure 1.

The appropriate boundary conditions at a loosely bonded interface z = 0 between elastic solid and viscoelastic porous solid half-spaces are

i. $\left(\tau_{zz}\right)_I = \left(\tau_{zz}\right)_{II} + \left(p_f\right)_{II}$,

ii. $\left(\tau_{xz}\right)_I = \left(\tau_{xz}\right)_{II}$,

iii. $\left(w\right)_I = \left(w\right)_{II}$,

iv. $\left(\dot{w} - \dot{W}\right)_{II} = \left(0\right)_I$,

v. $\tau_{xz} = \tau_0\left(u - u_e\right), \; \tau_0 = -ik\mu^* \frac{\psi}{1-\psi}\frac{1}{\sin\theta_0}$.

The appropriate potentials in elastic half- space are

$$\phi_e = A_0 e^{i(kx - d\alpha z - \omega t)} + A_1 e^{i(kx + d\alpha z - \omega t)}, \tag{13}$$

$$\psi_e = A_0^* e^{i(kx - d\beta z - \omega t)} + A_2 e^{i(kx + d\beta z - \omega t)}, \tag{14}$$

where $d\alpha = p.v.\left\{\left(\frac{\omega}{\alpha}\right)^2 - k^2\right\}^{\frac{1}{2}}$, $d\beta = p.v.\left\{\left(\frac{\omega}{\beta}\right)^2 - k^2\right\}^{\frac{1}{2}}$.

The appropriate potentials in viscoelastic porous solid half-space are

$$\phi_{11} = B_{11} e^{\left(-\vec{A}_{12}\cdot\vec{r}\right)} \cdot e^{i\left(\vec{P}_{12}\cdot\vec{r} - \omega t\right)}, \tag{15}$$

$$\phi_{12} = B_{21} e^{\left(-\vec{A}_{22}\cdot\vec{r}\right)} \cdot e^{i\left(\vec{P}_{22}\cdot\vec{r} - \omega t\right)}, \tag{16}$$

$$\psi = C_{12} e^{-\left(\vec{A}_{32}\cdot\vec{r}\right)} \cdot e^{i\left(\vec{P}_{32}\cdot\vec{r} - \omega t\right)}, \tag{17}$$

where, the propagation vectors $\vec{P}_{ij}$ and attenuation vectors $\vec{A}_{ij}$ are defined by

$$\vec{P}_{ij} = k_{\mathrm{Re}}\hat{x} + (-1)^j d\upsilon_{i_{\mathrm{Re}}}\hat{z}, \quad \vec{A}_{ij} = k_{\mathrm{Im}}\hat{x} + (-1)^j d\upsilon_{i_{\mathrm{Im}}}\hat{z}, \quad \text{with } d\upsilon_i = p\cdot\upsilon\left(\frac{\omega^2}{\upsilon_i^2} - k^2\right)^{\frac{1}{2}}.$$

where $C_{12} = (-\vec{C}_1)_y$, $\vec{C}_1$ is arbitrary complex vector chosen such that $\nabla\cdot\vec{\psi} = 0$, k is an arbitrary complex number such that $k_{\mathrm{Re}} \geq 0$ to ensure propagation in the positive x-direction. The subscripts Re and Im denote the real and imaginary parts of the corresponding complex quantities. Following Borcherdt (1982), the displacement potentials given by (13) to (17) satisfy the boundary conditions for all values of *x* provided that

$$k = k_{\mathrm{Re}} = \frac{\omega\sin\theta_0}{\alpha \text{ or } \beta} = \frac{\omega\sin\theta_1}{\alpha} = \frac{\omega\sin\theta_2}{\beta} = \left|\vec{P}_{12}\right|\sin\theta^*{}_1 = \left|\vec{P}_{22}\right|\sin\theta^*{}_2 = \left|\vec{P}_{32}\right|\sin\theta^*{}_3, \tag{18}$$

$$k_{\mathrm{Im}} = \left|\vec{A}_{j2}\right|\sin\left(\theta^*{}_j - \gamma_j\right), \ (j = 1,2,3) \tag{19}$$

Which is the extension of Snell's law. We also obtain the following non-homogeneous system of five equations

$$\sum_{J=1}^{5} a_{ij} Z_j = b_i, \ (i = 1,2,..,5), \tag{20}$$

where

$$a_{11} = -\lambda k^2 - (\lambda + 2\mu)(d\alpha)^2, \ a_{12} = 2\mu k d\beta,$$

$$a_{13} = \left(H^* - \alpha^* M^*\right)(d\upsilon_1)^2 + k^2\left\{\lambda^* + \alpha^{*2} M^* - \alpha^* M^*\cdot(1-\mu_1) - \mu_1 M^*\right\}$$

$$+\mu_1\left(\alpha^* M^* - M^*\right)\cdot(d\upsilon_1)^2,$$

$$a_{14} = \left(H^* - \alpha^* M^*\right)(d\upsilon_2)^2 + k^2\left[\lambda^* + \alpha^{*2} M^* - \alpha^* M^*(1-\mu_2) - \mu_2 M^*\right]$$

$$+\mu_2\left(\alpha^* M^* - M^*\right)\left(dv_2\right)^2,$$

$$a_{15} = kdv_3\left(H^* - \lambda^* - \alpha^{*2} M^*\right),$$

$$a_{21} = -2\mu k\, d\alpha,\ a_{22} = -\mu\left[\left(d\beta\right)^2 - k^2\right],\ a_{23} = -2\mu^* k\, dv_1,$$

$$a_{24} = -2\mu^* k\, dv_2;\ a_{25} = \mu^*\left[\left(dv_3\right)^2 - k^2\right]$$

$$a_{31} = d\alpha,\ a_{32} = -k,\ a_{33} = dv_1,\ a_{34} = dv_2,\ a_{35} = k,$$

$$a_{41} = 0,\ a_{42} = 0,\ a_{43} = -\left(1-\mu_1\right)dv_1,\ a_{44} = -\left(1-\mu_2\right)dv_2,$$

$$a_{45} = -\left(1-\alpha_0\right)k,$$

$$a_{51} = ik\tau_0;\ a_{52} = id\beta\tau_0;\ a_{53} = 2kdv_1\mu^* - ik\tau_0;$$

$$a_{54} = 2kdv_2\mu^* - ik\tau_0;\ a_{55} = i\tau_0 dv_3 - \mu^*\left\{\left(dv_3\right)^2 - k^2\right\}$$

$$a_{51} = k^2\frac{\psi}{1-\psi}\cdot\frac{1}{\sin\theta_0},\ a_{52} = kd\beta\frac{\psi}{1-\psi}\cdot\frac{1}{\sin\theta_0}$$

$$a_{53} = 2kdv_1 - k^2\frac{\psi}{1-\psi}\cdot\frac{1}{\sin\theta_0},\quad a_{54} = 2kdv_2 - k^2\frac{\psi}{1-\psi}\cdot\frac{1}{\sin\theta_0},$$

$$a_{55} = kdv_3\frac{\psi}{1-\psi}\cdot\frac{1}{\sin\theta_0} - \left\{\left(dv_3\right)^2 - k^2\right\},$$

(a) For incident *P* wave,

$$b_1 = -a_{11},\ b_2 = a_{21},\ b_3 = a_{31},\ a_{41} = b_4,\ b_5 = -a_{51},$$

and

$$Z_1 = \frac{A_1}{A_0},\ Z_2 = \frac{A_2}{A_0},\ Z_3 = \frac{B_{11}}{A_0},\ Z_4 = \frac{B_{21}}{A_0},\ Z_5 = \frac{C_{12}}{A_0},$$

Are amplitude ratios of reflected *P*, reflected *SV*, refracted P_{12}, refracted P_{22} and refracted P_{32} waves, respectively.

a) For Incident SV wave,

$$b_1 = a_{12},\ S_v:\ b_2 = -a_{22},\ b_3 = -a_{32},\ a_{42} = b_4,\ b_5 = a_{52};$$

and

$$Z_1 = \frac{A_1}{A_0^*},\ Z_2 = \frac{A_2}{A_0^*},\ Z_3 = \frac{B_{11}}{A_0^*},\ Z_4 = \frac{B_{21}}{A_0^*},\ Z_5 = \frac{C_{12}}{A_0^*},$$

Are amplitude ratios of reflected *P*, reflected *SV*, refracted P_{12}, refracted P_{22} and refracted P_{32} waves, respectively. For $\psi = 1$, the above system of equations (20) reduces for welded interface.

V. Numerical Results and Discussion

For numerical computations of reflection and transmission coefficients, we resolve the operators $\lambda^*, \mu^*, \gamma^*$ and δ^* into their real and imaginary parts, for a general linear viscoelastic solid. Following Biot (1962), the operators γ^* and δ^* are approximated by elastic coefficients, i.e. $\gamma^* = \gamma,\ \delta^* = \delta$. Following Silva (1976), we write $\mu^* = \mu_R\left(1 + iQ_s^{-1}\right)$, and $\lambda^* + 2\mu^* = \left(\lambda_R + 2\mu_R\right)\left(1 + iQ_e^{-1}\right)$, where Q_e^{-1} and Q_s^{-1} are compressional specific attenuation and shear specific attenuation, respectively. Subscript *R* denotes the real parts of the corresponding quantities. Following Biot (1956b), Poiseuille flow breaks down if frequency $f\left(=\omega/2\pi\right)$ exceeds a certain value f_t given by $f_t = \dfrac{\pi\eta}{\rho_f 4d^2}$, where *d* is the diameter of the pores. If the pores behave like circular tubes, then $f_t f_c = 0.154$, where $f_c = \eta\beta / \chi 2\pi\rho_f$ is the characteristic frequency. Therefore, we are restricted to the frequency range $0 < \dfrac{f}{f_c} < \dfrac{f_t}{f_c} = 0.154$. Following Murphy III (1982), we consider water-saturated Massilon-sandstone with the following parameters: Porosity = 23 per cent, Grain density = 2.66 gm/cm^3, Pore diameter = 3×10^{-3} cm. Following Biot (1956b), in case of water in the pores at 15°C, we find $f_t = \dfrac{10000}{9}$ Hertz for $d = 3 \times 10^{-3}$ cm. Specific attenuation Q_e^{-1} and Q_s^{-1} in partially Massilon-sandstone are strongly frequency dependent. However, dependence is weak only in very dry rocks or in wetted rocks (100 per cent saturation). Following Murphy III (1982) for 100 per cent water-saturated Massilon-sandstone, we choose $Q_e^{-1} = 0.04$ and $Q_s^{-1} = 0.047$ at $f \sim 560$ Hz. Hence we find $\dfrac{f}{f_c} = 0.0776$ approx, and $\dfrac{\eta}{\omega\chi} = \dfrac{\rho_t}{\beta\dfrac{f}{f_c}}$, where ρ_f is the density of interstitial water and is assumed to be 1 gm/cm^3. Following Zwikker and Kosten (1949), Biot's parameter *m* may be expressed as $m = \dfrac{c\rho_f}{\beta};\ c \geq 1$, where, for uniform circular pores with axes parallel to the pressure gradient, *c* would be equal to 1.

Following Fatt (1959) and Yew and Jogi (1976) relevant elastic parameters for water-saturated sandstone are chosen to be

$$\delta = 0.73787 \times 10^{-11}\left(dynes/cm^2\right)^{-1},\ \gamma = 0.889 \times 10^{-11}\left(dynes/cm^2\right)^{-1}$$

$$\mu_R = 0.922 \times 10^{11}\ dynes/cm^2,\ \lambda_R = 0.3032 \times 10^{11}\ dynes/cm^2.$$

Following Bullen (1963), the material constants of granite as elastic half-space are considered as

$$\lambda = 2.238 \times 10^{11}\ dynes/cm^2,\ \mu = 2.992 \times 10^{11}\ dynes/cm^2, \rho = 2.66\ gm/cm^3.$$

Using all the above numerical values and equations (18) and (19), the reflection and transmission coefficients Z_1, Z_2, Z_3, Z_4 and Z_5, given by (20), are computed for incident *P* and *SV* waves. The angle of incidence θ_0, is considered to be varying from normal incidence $\left(\theta_0 = 0°\right)$ to grazing incidence $\left(\theta_0 = 90°\right)$. We restrict the numerical computations for homogeneous case only.

a) Loosely Boundary Effect

i. *Incident P wave*

The amplitude ratios of reflected *P* and *SV* waves for ψ = 0.25, 0.5, 0.75 and 1.0 are plotted against the angle of incidence ($0° < \theta_0 < 90°$) of *P* wave. These variations are shown in Figures 2 and 3 by black, blue, red and green curves, respectively. In each case, the amplitude ratios of reflected *P* and *SV* waves are same at normal and grazing incidence. The comparison of the different curves shows the effect of loose boundary on amplitude ratios of reflected *P* and *SV* waves. This effect is observed maximum in the range $45° < \theta_0 < 90°$. The amplitude ratios of refracted P_{12}, P_{22} and P_{32} waves for ψ = 0.25, 0.5, 0.75 and 1.0 are plotted against the angle of incidence of *P* wave. These variations are shown in Figures 4 to 6 by black, blue, red and green curves, respectively. These amplitude ratios are also affected due to loosely boundary at angles other than grazing and normal incidence.

ii. *Incident SV wave*

The amplitude ratios of reflected *P, SV* waves and refracted P_{12}, P_{22} and P_{32} waves for ψ = 0.25, 0.5, 0.75 and 1.0 are plotted against the angle of incidence ($0 < \theta_0 < 50$) of *SV* wave also. These variations are

shown in Figures 7 to 11 by black, blue, red and green curves, respectively. The comparison of the different curves shows the effect of loosely boundary on amplitude ratios of reflected and refracted waves.

b) Viscoelastic effect

To observe the viscoelastic effect on reflected and transmitted coefficients, we consider the incidence of *P* wave and $\psi = 0.25$. On comparing the solid and dotted curves in Figures 12 to 16, it can be seen that the coefficients of reflected and transmitted waves change due to viscoelastic effect.

VI. Concluding Remarks

Relations between reflection and transmission coefficients are obtained for incident of P and SV at a loosely bonded interface between an elastic solid half-space and a viscoelastic porous solid half-space. Numerical values of these coefficients are computed for a particular model of the interface. It is observed that these coefficients are affected significantly due to the presence of loosely boundary. These coefficients are also affected due to the presence of viscoelasticity in upper half-space.

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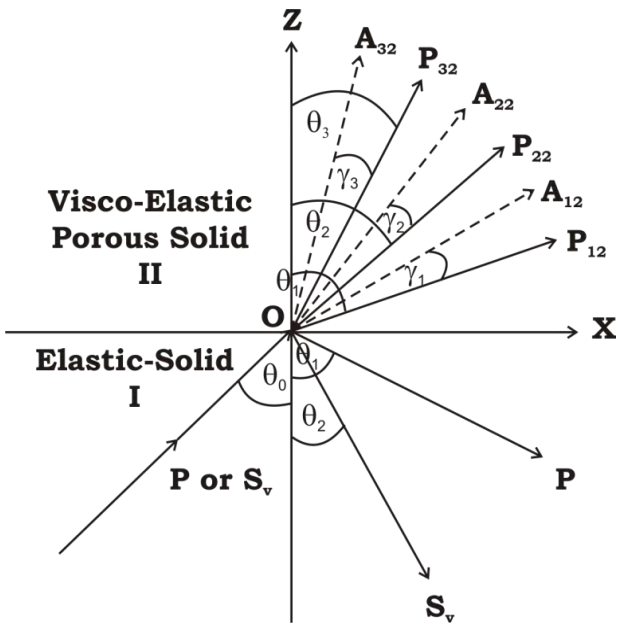

Figure 1 : Geometry of the problem

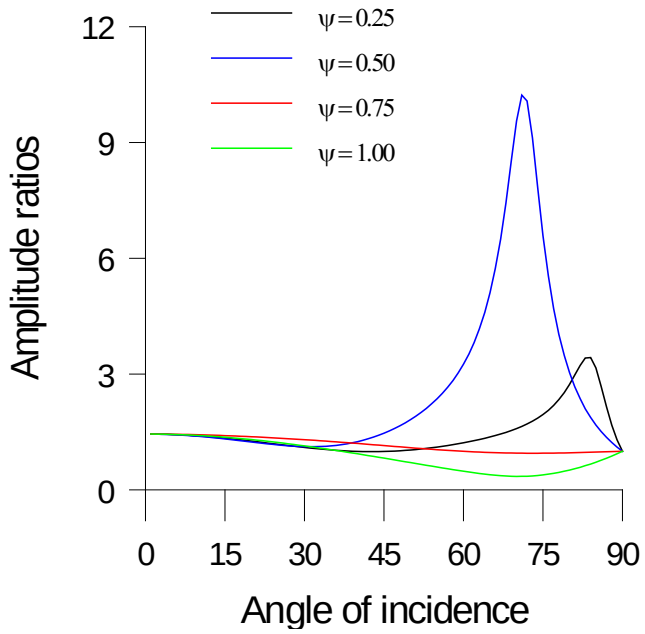

Figure 2 : Variations of the amplitude ratios of reflected *P* wave against the angle of incidence of *P* wave for different values of loosely bonded parameter.

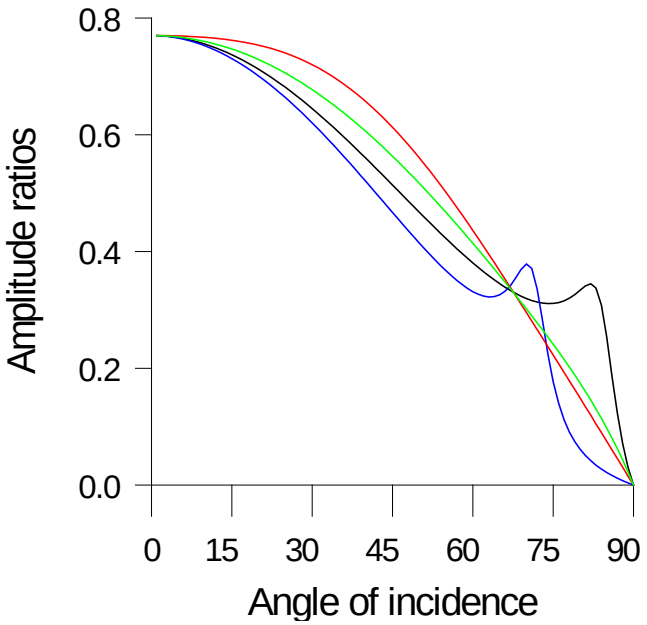

Figure 4 : Variations of the amplitude ratios of reflected P_{12} wave against the angle of incidence of *P* wave for different values of loosely bonded parameter

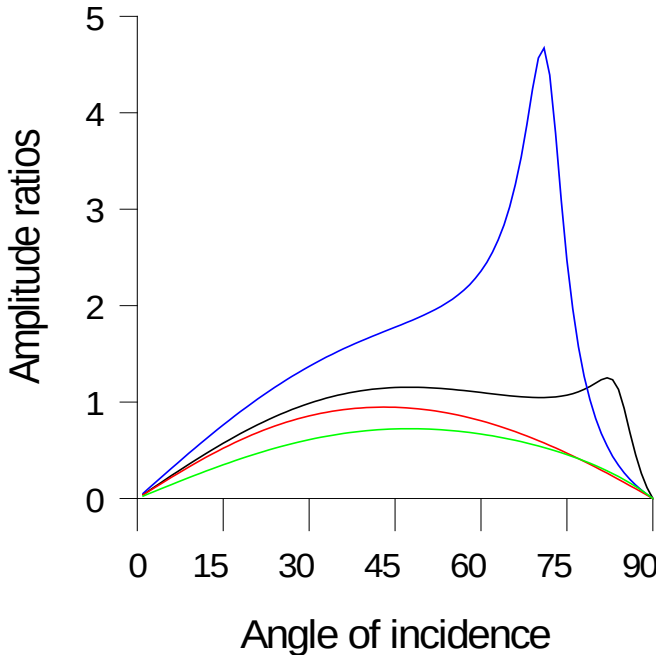

Figure 3 : Variations of the amplitude ratios of reflected *SV* wave against the angle of incidence of *P* wave for different values of loosely bonded parameter

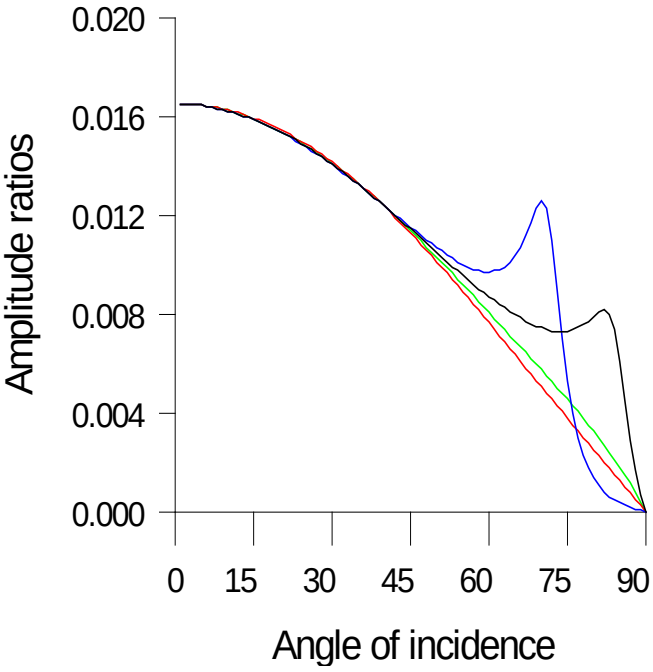

Figure 5 : Variations of the amplitude ratios of reflected P_{22} wave against the angle of incidence of *P* wave for different values of loosely bonded parameter

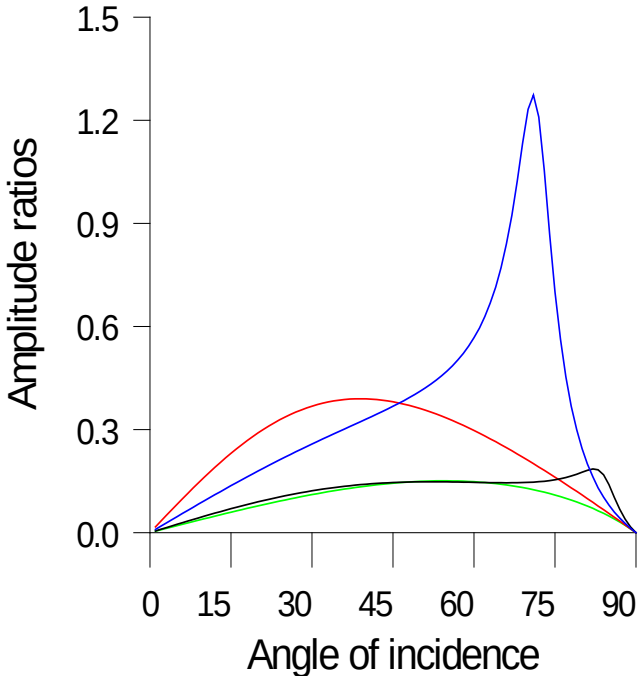

Figure 6 : Variations of the amplitude ratios of reflected P_{32} wave against the angle of incidence of *P* wave for different values of loosely bonded parameter

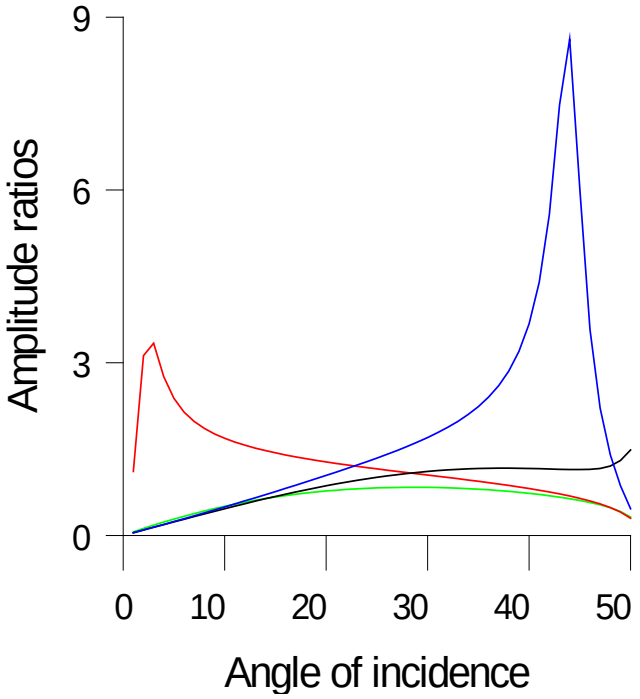

Figure 8. Variations of the amplitude ratios of reflected *SV* wave against the angle of incidence of *SV* wave for different values of loosely bonded parameter.

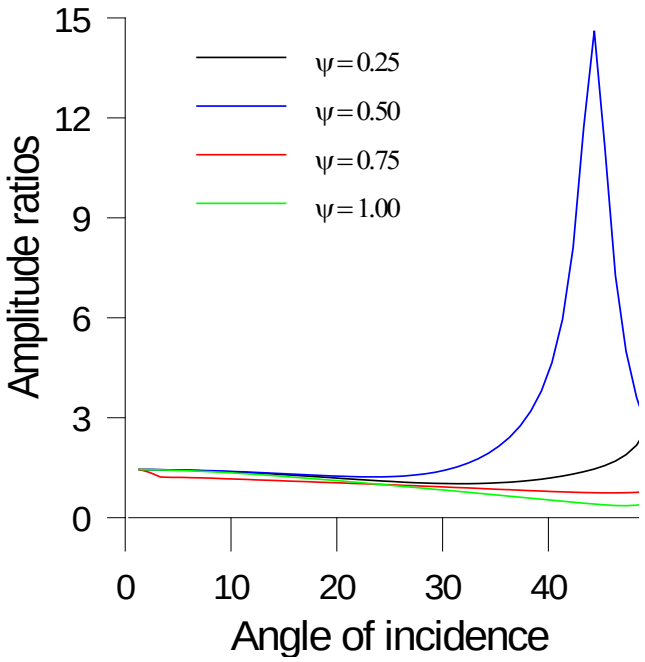

Figure 7 : Variations of the amplitude ratios of reflected *P* wave against the angle of incidence of *SV* wave for different values of loosely bonded parameter

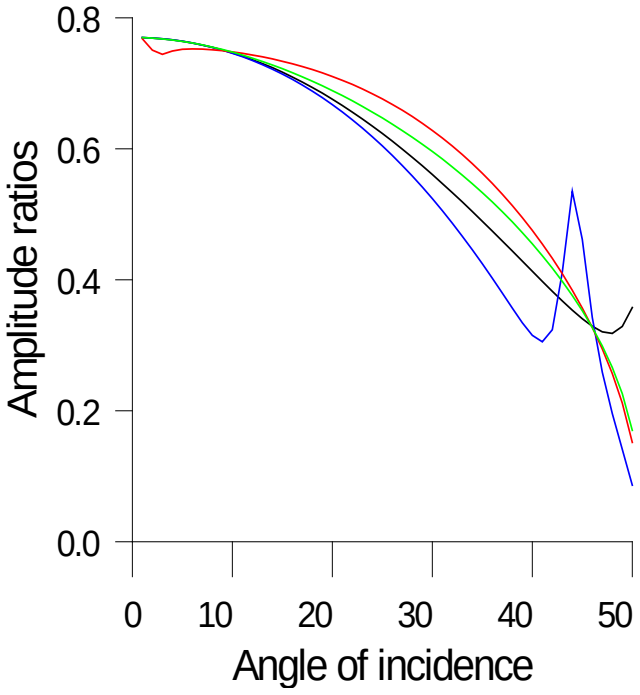

Figure 9 : Variations of the amplitude ratios of reflected P_{12} wave against the angle of incidence of *SV* wave for different values of loosely bonded parameter

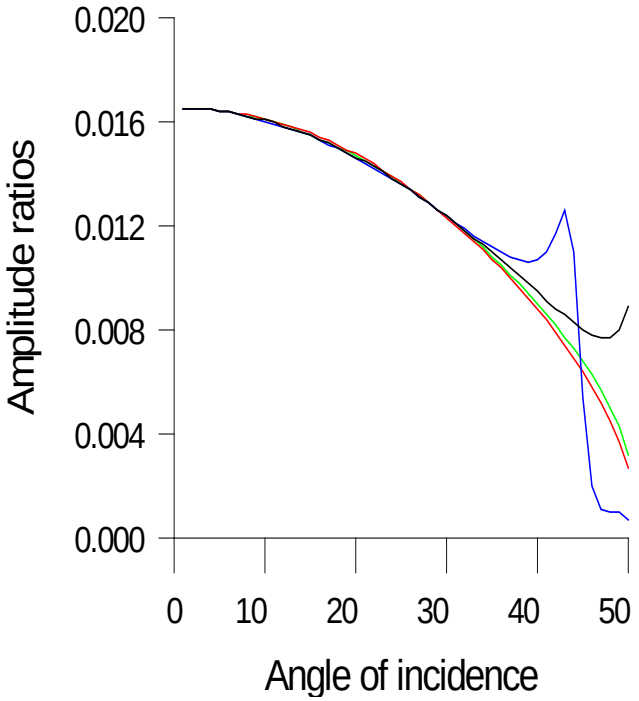

Figure 10 : Variations of the amplitude ratios of reflected P_{22} wave against the angle of incidence of SV wave for different values of loosely bonded parameter

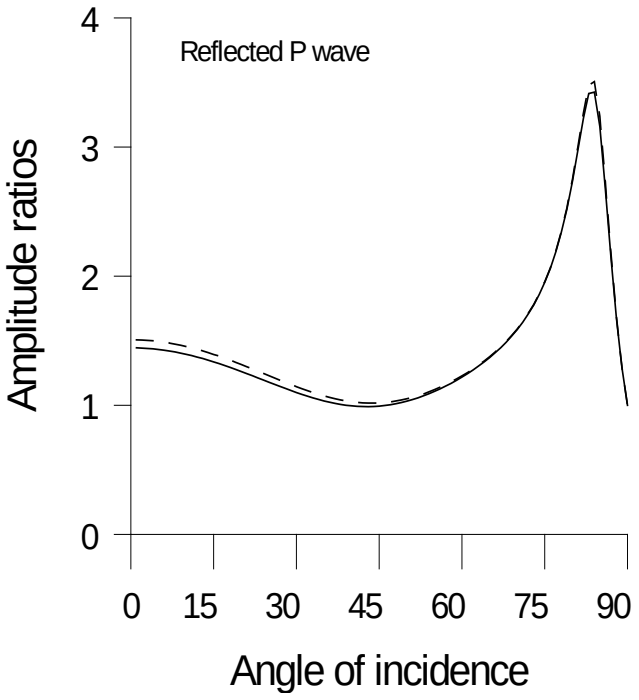

Figure 12 : Viscoelastic effect on the amplitude ratios of reflected *P* wave against the angle of incidence of *P* wave for $\psi = 0.25$

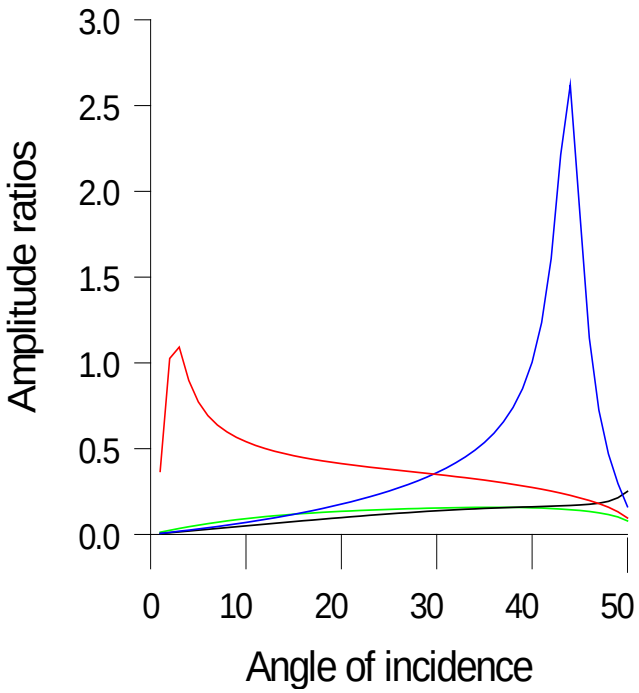

Figure 11 : Variations of the amplitude ratios of reflected P_{32} wave against the angle of incidence of *SV* wave for different values of loosely bonded parameter

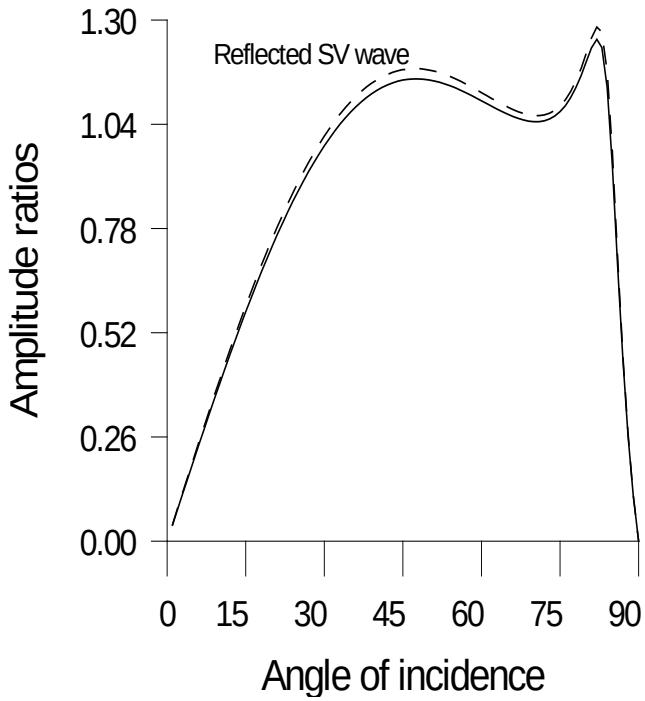

Figure 13 : Viscoelastic effect on the amplitude ratios of reflected *SV* wave against the angle of incidence of *P* wave for $\psi = 0.25$

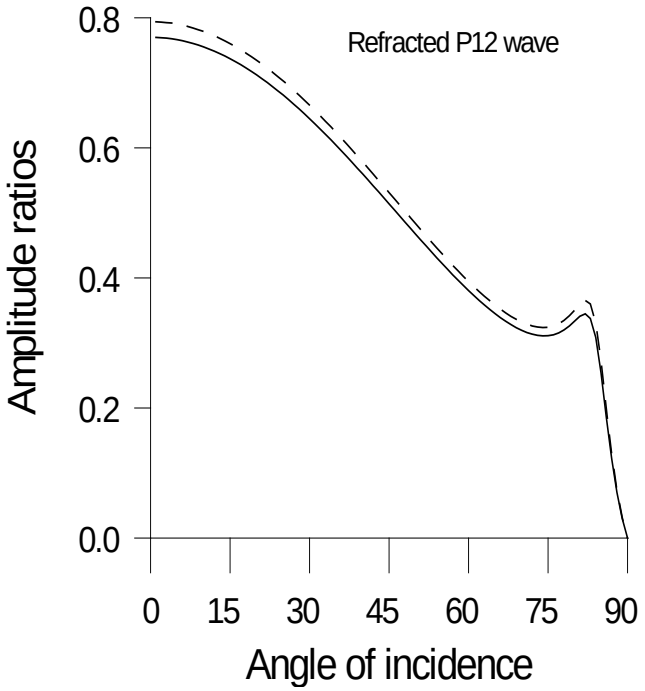

Figure 14 : Viscoelastic effect on the amplitude ratios of transmitted P_{12} wave against the angle of incidence of P wave for $\psi = 0.25$

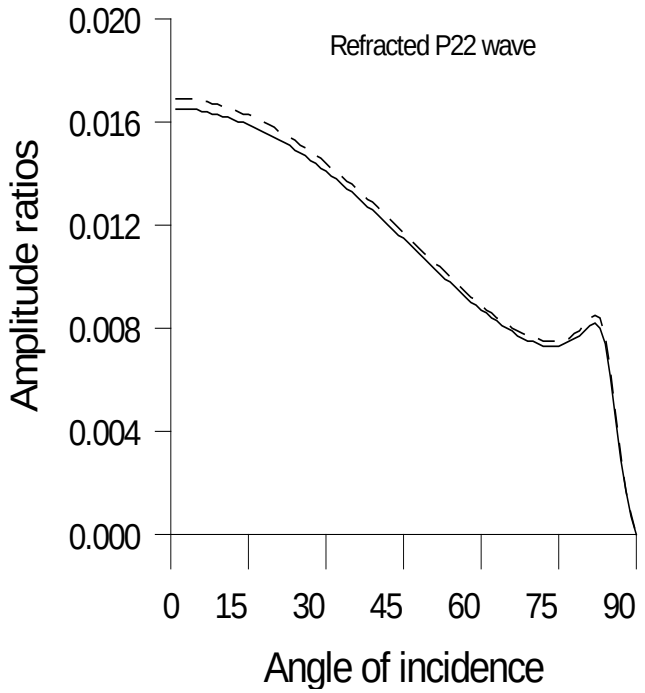

Figure 15 : Viscoelastic effect on the amplitude ratios of transmitted P_{22} wave against the angle of incidence of P wave for $\psi = 0.25$

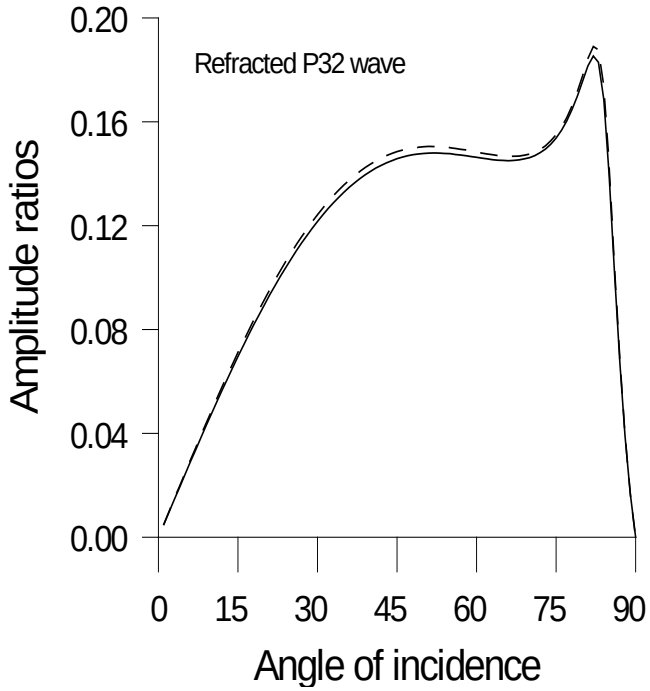

Figure 16 : Viscoelastic effect on the amplitude ratios of transmitted P_{32} wave against the angle of incidence of P wave for $\psi = 0.25$

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Assessment of Students' Information Literacy and Information Fluency Competency: A Case Study in Japan

By Eiko Takaoka
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Abstract- This paper describes the assessment of the competency of students' information literacy and information fluency in order to obtain the levels of university student competency in Japan. As the results, a significant difference occurred between pre- and post-tests for all courses. The difference indicates that the students' skill improved through these courses. In addition, although year-to-year differences occurred, no overall trend was seen. For mixed-year courses, no difference occurred in the school year. The result of the investigation about difficult fields for students to understand revealed that students tend not to understand accurate definitions of technical terms and lack net manners regarding sending email. The results will contribute to the course design of an information fluency course in the future.

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Abstract- This paper describes the assessment of the competency of students' information literacy and information fluency in order to obtain the levels of university student competency in Japan. As the results, a significant difference occurred between pre- and post-tests for all courses. The difference indicates that the students' skill improved through these courses. In addition, although year-to-year differences occurred, no overall trend was seen. For mixed-year courses, no difference occurred in the school year. The result of the investigation about difficult fields for students to understand revealed that students tend not to understand accurate definitions of technical terms and lack net manners regarding sending email. The results will contribute to the course design of an information fluency course in the future.

I. Introduction

"Digital natives", who are the generation of young people born in the digital age, are assumed to be inherently savvy in technology [1]. Students often use "cloud" applications such as Facebook, Twitter, and GoogleDocs as their learning environments. Taking pictures with a smartphone of the projection screen happens far too frequently in the classroom. "Information literacy" and "information fluency" are the two main terms that consider the skills needed to use computers and access information. However, the definitions of these terms vary.

Many countries have judged that it is essential to offer educational programs in information fluency for students to prepare for life and work in today's world, in which our information society continues to expand. However, differences regarding educational style exist between Western countries and non-Western countries. Education in Western countries tends toward a student-centered style, but the education in non-Western countries tends toward a teacher-centered style.

Given such a background, this paper describes the assessment of students' information literacy and information fluency competency in order to assess the levels of university student competency in Japan. In addition, the results of investigation of the students' performances are also described.

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II. Related Work

a) Information Literacy and Information Fluency

Three terms regarding the skills needed to use computers and to access information are "information literacy", "IT fluency", and "information fluency".

The term "information literacy" is relatively new. It was first employed in a report by the 1974 National Commission on Libraries and Information Science [2]. The report describes the skills needed to use a variety of information tools to access and synthesize information from primary and other sources. However, as digital technologies have grown in importance, definitions of information literacy have expanded to include their specific uses [3].

In 1999, the National Research Council Committee on Information Technology Literacy proposed the new term "IT fluency", which is the requisite knowledge and skills of IT-fluent students promulgated by a group of experts from research and academic computing communities [4,5]. In addition, Ref. [5] explored three diverging concepts and terms—information literacy, IT fluency, and information fluency—and described the emerging connections and discussions concerning information literacy and IT fluency between and among various levels of education in the United States. The author also stated the following regarding "information fluency":

> *Due to all of the discussion concerning the development of these terms that describe accessing, evaluating, and using information, a new concept has emerged in recent years called information fluency. This concept blends many of the characteristics of traditional information literacy and IT fluency and similar concept such as digital literacy, or e-learning.*

Since then, the term "information fluency" has proliferated: in Ref. [6], a search engine generated approximately 2,267,400 results in 2.54 seconds on 4 March 2011 for the number of information fluency-related terms and an additional 14,139,700 results a month later. This study focuses on the two terms "information literacy" and "information fluency", which includes information literacy, IT fluency, and similar concepts.

Ref. [7] proposed that the modern or contemporary classroom should enhance the learning experience and promote twenty-first century competencies and concluded that having a successful hybrid learning (use of face-to-face instructional methods and various learning technologies) environment is important.

Our university has required programs in information literacy since 2001. The students obtain the ability to use computer applications and the Internet in the following ways: to write, search, and evaluate programs; to use and manage information; and to create web pages and gain knowledge of the social and legal implications. In 2008, we conducted 34 information literacy classes (50–80 students per class). In 2003, information study became a required course in most high schools in Japan. Because students had learned the rudimentary knowledge in high school, the university curriculum was reorganized on the basis of the results of a questionnaire survey of the knowledge level of freshmen, and an introductory class was added as a traditional course.

Since then, the curriculum was reorganized again with the development of information technology, and the courses regarding information literacy as required courses were abolished and a wide range of courses on information fluency were provided as electives [8,9]. Table 1 shows the course catalog for the categories "Information Literacy" and "Information Fluency".

Table 1 : Course catalog for "Information Literacy" and "Information Fluency"

Category	Course Title	Number of classes	Number of students
Information Literacy	Introduction To Information Literacy	1	around 80
	General	14	around 40 - 80
	Information Retrieval and Searching	2	90
	Statistics	2	around 30
	Data Transactions	2	90
	English Version	2	44
	Information Science	2	80
Information Fluency	Systematic Information Processing	1	44
	Programming Method	2	80
	Systems Consulting	1	80
	OOP & JAVA	1	19
	Informatics and Human Interaction	1	90
	Multimedia Communication	1	44
	Media and Networking Technology	1	20
	Informatics and Digital Network Interactions	1	36
	IT Passport Exam I *	1	36
	IT Passport Exam II	1	40
	Fundamental Course Excel Transactions	1	66
	Advanced Course in Excel Transactions	1	80
	Web Pages in HTML and CSS	1	44
	C Programming	1	36
	Excel Transaction by VBA	1	80
	Game Programming	1	44

*IT passport is a Japanese national examination regarding fundamental knowledge of IT.

The goal of this discipline is that students obtain the knowledge and skill for living in a world in which our information society continues to expand.

All of the courses are basically conducted as hands-on exercise lessons in the computer room. That is, students are required to create something by using a computer application or students in a course must configure their computer to communicate on the Internet. Most courses are teacher-centered lectures, although some courses adopt the student-centered approach.

The author taught the Information Literacy course from 2008 to 2010, and has continued to teach the information fluency course, Informatics and Human Interaction (see shaded area in Table 1), since 2011. In addition, the author has taught Computers and Human Interaction, which is similar to Informatics and Human Interaction, at another university since 2010. The details are described later in the Methods section. In Informatics and Human Interaction as well as Computers and Human Interaction, the author adopted blended style lectures, that is, the first half of a lesson follows a teacher-centered style and the last half follows a student-centered style that includes discussion, peer-review, and so on. It is known that it is difficult for some Japanese students to join in the discussions. However, the author did not force such students to join and a brief period of discussion seems to be acceptable for most students.

In the course, the author carried out student assessments of contemporary skills. The assessment was the same during 2008–2011 and in 2014.

This article reports the results of the questionnaire survey for suggesting the direction for future research regarding what students are not able to understand and how lecturers should compose our course curriculum.

b) Information and Communication Technology (ICT) competence

Various reports have investigated the measurement of information literacy and information fluency competence [10-14]. In Ref. [10], Aesaert et al. state that most of the measures that have been developed are directed toward students' ICT self-efficacy, which is mostly measured by using a Likert scale. A big disadvantage of a Likert scale is that we cannot exactly assess how competent a pupil is, because the different positions on the scale are not assumed to be equally spaced.

c) Teaching Style

In Ref. [6], the author suggests the following.

> *amongst the estimated two billion Internet users worldwide in 2010, approximately 61% are from countries in Asia, the Middle East, the Caribbean and South America.(p.15)*

In addition, the author added a variety of discussions that focused on whether the Western educational approach of information fluency could be applied to non-Western country students because the culture and the education system are different between Western countries and non-Western countries, as follows.

> *Education systems in countries like China, Taiwan, and Japan are interpreted as conservative and teacher-centered.(p.15)*
>
> *The expectation might be that education in these countries is not really geared to embrace IF and would resist it as a foreign way of thinking brought on by globalization. (p16)*

However, the author described the following.

> *Watkins (1998) and Biggs (2003) noted that research has established that, in practice, much of the university teaching in countries such as Australia and the United States is more about lecturers being knowledgeable about their subject and imparting this knowledge to their students in a teacher-directed fashion. (p.17)*
>
> *Watkins, D. (1998). A cross-cultural look at perceptions of good teaching: Asia and the West. In J. Forest (Ed.), University teaching: International perspectives (pp. 19-34). New York: Garland Publishing, Inc.*
>
> *Biggs, J. (2003). Teaching for quality learning at university (2nd ed.). Maidenhead: Open University Press.*

Another article [15] stated the following.

> *The Academic Achievement Challenge: What Really Works-in the Classroom by the late Jeanne S. Chall makes the assertion, sure to be controversial, that a traditional, teacher-centered approach generally results in higher academic achievement.*

On the other hand, Ref. [16] evaluated web searching competency based on students' searching performance. The participants included 141 undergraduate and graduate students from Wuhan University, China. The results are described as follows.

> *Competency levels for searching academic tasks were higher than those of daily-life tasks, especially when the degree of difficulty increased. In information literacy education it is therefore vital to teach students comprehensive web searching competency that includes knowledge and techniques for both academic and daily-life search tasks.*

Therefore, in this study, we evaluated competency levels for information literacy and information fluency of students who took a course in

information literacy or information fluency during 2009–2011 and in 2014.

Moreover, this study used performance-based tasks to develop a direct measure of ICT competence.

III. Method

Three courses are described in this paper: Information Literacy, and Information and Human Interaction at our university ("S" university in Tables 2, 3, and 5), and Computers and Human Interaction at "I" University. The Information Literacy course was a required subject for freshmen (2009–2010). The author has been teaching the new course Information and Human Interaction, which is an elective subject for all years of students (after 2011). Both this course and Information Literacy consist of one 90-minute period per week for 14 weeks. Our university is on the semester system, but "I" University is not (three terms per year). "Computers and Human Interaction" at "I" University is an elective subject for all years of students and consists of three 70-minute periods per week for 10 weeks. Course schedules are shown in Table 2. Although a few minor changes are made every year for each subject, the contents of the courses remain about the same.

For all of the courses, students typically submit their assignments to the Moodle (Modular Object-Oriented Dynamic Learning Environment), an open-source course management system, for each class, watch short video clips regarding information ethics (computer viruses, intellectual property rights, net manners, and so on) and they hand in a term paper at the end of the semester.

Table 2 : Course schedules

Information Literacy ("S" university)
Orientation
Touch Typing
How to Use the Informational Service of the Library
Touch Typing
Writing
Writing (advanced)
Spreadsheet (simple calculations)
Spreadsheet (using functions)
Spreadsheet (macros)
Making a Presentation
Programming Language (HTML)
Net Manners
Information Ethics
General Overview
"Information and Human Interaction" ("S" university)
Orientation
Internet Mechanism
How Email Works, How Web Communication Works
Media Literacy
Information Ethics
Intellectual Property Rights
Privacy and Security
How Information Is Represented in the Computer
What Computation Is

Hardware Configuration
Overview of Information Systems
Programming Language (Dolittle)
Programming Language (Scratch)
The Role of Humans in this Information Society
Computer and Human Interaction ("I" university)
Orientation, Programming Language (Dolittle)
Internet Mechanism
How Email Works, How Web Communication Works
Media Literacy
Information Ethics
Intellectual Property Rights
Privacy and Security
How Information Is Represented in the Computer
Fundamental Information - Communication What Computation Is
The Role of Humans in this Information Society

Table 3 shows an overview of the courses and the students' performance in the pre- and post- tests. In this table, "M" is the mean, "SD" is the standard deviation. The "Number" column indicates the number of valid responses of an assessment, that is, the number of students who took both the pre- and post-tests.

Table 3 : Overview of the courses and the students' performance

Year	Course	Faculty	School Year	Pre-test M (SD)	Post-test M (SD)	Number	Type	Univ.
2009	Information Literacy	Foreign Studies	Freshman	20.8 (2.6)	22.5 (2.0)	55	required	S
2010	Information Literacy	Foreign Studies	Freshman	19.0 (2.9)	20.9 (3.8)	45	required	S
2010	Computers and Human Interaction	mix	mix	22.4 (1.9)	23.4 (1.8)	52	elective	I
2011	Informatics and Human Interaction	mix	mix	21.5 (2.5)	23.6 (2.3)	30	elective	S
2011	Computers and Human Interaction	mix	mix	21.3 (3.2)	22.6 (3.1)	60	elective	I
2014	Informatics and Human Interaction	mix	mix	N/A	22.0 (2.7)	65	elective	S

As stated above, the student assessment has two major components: a pre-test and a post-test (through 2011). In the pre- and post-tests, students were asked to answer 25 questions (1 point for each question except Question 1) in 7 parts to assess their skills. Table 4 shows the details of the questions.

Table 4 : Details of the pre- and post-tests

Total points: 26	Description	Question/Detail
Part 1 (2 points)	Identifying accurate/inaccurate statements about extension of file	1 / regarding the file whose extension is .exe
Part 2		2 / .txt
		3 / .ppt
		4 / .doc
		5 / .docx

Part 3	Understanding the meaning of BCC and CC	6 /
Part 4	Identifying the case of violation of law or infringement of rights	7 / uploading something to the Internet
		8 / private use
		9 / private use
		10 / uploading something to the Internet
		11 / uploading something to the Internet
		12 / uploading something to the Internet
Part 5		13 / copyright-protected period in Japan
Part 6	Identifying accurate/inaccurate statements about information ethics	14 / evaluating the appropriateness for forwarding messages (e.g., chain e-mail)
		15 / keeping personal information
		16 / gaining a correct understanding of the hazards of chatting with strangers
		17 / net manner (no-subject e-mail)
		18 / net manner (being polite)
		19 / forwarding a message without acquiring permission from the sender
		20 / sending message without writing your identities
Part 7	Identifying accurate/inaccurate statements about computer virus	21 / definition of computer virus
		22 / dealing with computer virus infection
		23 / How a computer gets infected with a virus or spyware?
		24 / necessity of seeing what it is when getting email from strangers
		25 / necessity of keeping one's antivirus software's virus definition files updated

IV. Analysis

a) Students' performance (Course evaluation)

The results of a paired samples two-sided t-test between the pre- and post-tests for each course showed a significant difference between the two tests for all courses. A P value less than 0.01 was considered statistically significant. The results indicate that the students' skill improved through these courses.

b) Year-to-year difference

Is there any difference between years? The results of an independent samples t-test assuming unequal variances (P value less than 0.01 was considered statistically significant) are shown in Table 5 for "S" university. For both the pre- and the post-tests, the performance in 2011 is higher than that in 2010. The 2011 performance of the post-test is the highest of all four years.

The new course started in 2011 and the number of students who took the course was less than that in other years; therefore, the number of students is considered to be the reason for the highest score. The importance of small-group teaching to foster engagement with educationally effective practices was shown [17,18]. In addition, we offered a face-to-face class with small-group instruction for the weaker students, while we provided the fully online course for the regular students. We succeeded in helping the weaker students to overcome their programming phobia and to develop the ability to create basic programs [19]. The importance of small-group teaching was thus reaffirmed.

In contrast, the results comparing 2010 and 2011 of "I" university by using an independent samples t-test assuming unequal variances (P value less than 0.05 was considered statistically significant) indicates that a significant difference occurred (2010 results were higher than those in 2011).

Table 5 : Year-to-year difference of "S" university

Pre-test (S)	2009	2010	2011	
Average score	20.8	19.0	21.5	
2009	-			
2010	**	-	**	
2011			-	
Post-test (S)	**2009**	**2010**	**2011**	**2014**
Average score	22.5	20.9	23.6	22.0
2009	-		*	
2010	+	-	**	
2011			-	
2014			**	-

***: significant difference in the two-sided t-test; *: significant difference in the one-sided test; +: two-sided test with a P value between 0.01 and 0.05.*

Consequently, although year-to-year differences occurred, no overall trend was seen.

c) Difference between types of school year

Regarding the mixed-year courses, is there any difference between the types of school year? The result of a two-sided t-test for independent samples assuming unequal variances (P value less than 0.01 was considered statistically significant) indicates that no significant difference occurred between the types of school year.

d) Difficult fields for students to understand

We analyzed what questions resulted in a lower student performance. Figure 1 shows the percentage of questions answered correctly for both pre- and post-tests without "S" university in 2014 only.

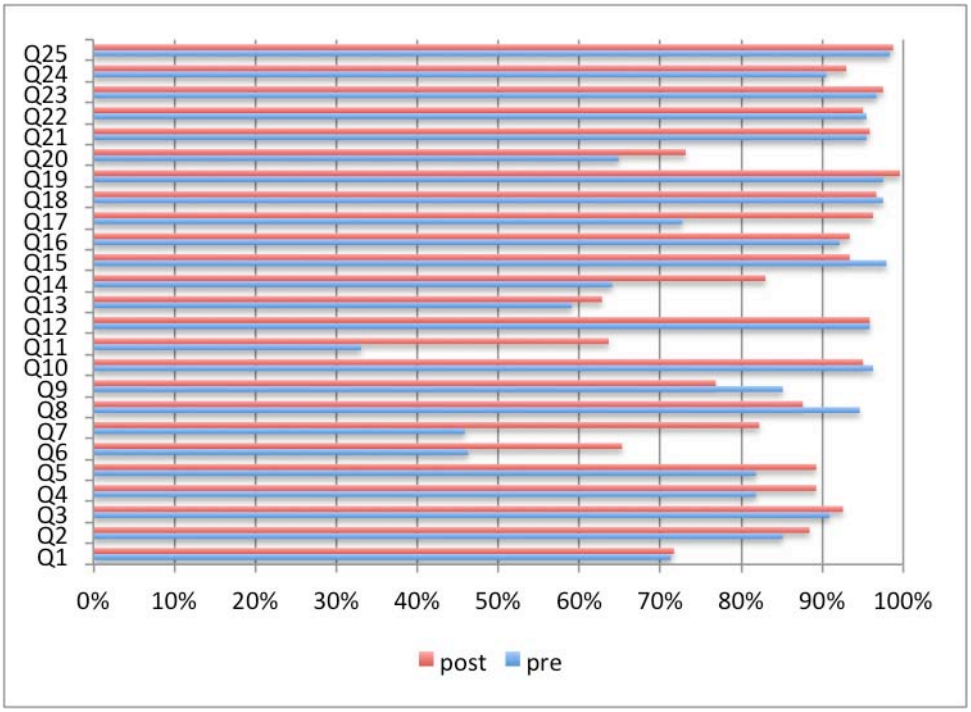

Figure 1 : Students' performance for post- and pre-tests: The percentage of questions answered correctly (without "S" university in 2014 only)

Lower rates are shown for questions 11, 7, 6, 13, 14, 20, 1 for the pre-test and questions 13, 11, 6, 1, 20, 9, 7, 14 for the post-test, in order of increasing number of students answering correctly. Question 11 and Question 7 are both about uploading something to the Internet. Question 11 is "You uploaded a music video where you played a very common song on the piano to your website" and Question 7 is "You uploaded the picture of a famous character you drew to your website". As shown in Figure 2, Question 6 is about understanding the meaning of BCC and CC.

BCC and CC are expected to be well known now as compared with a decade ago. The reason why the accuracy rate was low could be that this question was worded as "Select WRONG statement" instead of "Select RIGHT statement". However, if students did not correctly select "wrong statement", does this result indicate that the students did not fully understand the question? Question 13 is about the copyright-protected period in Japan: "How long do the author's rights continue?" The answer is "In principle, 50 years after the author's death". As shown in Figure 3, Question 1 is about the file whose extension is .exe.

Question 13 and Question 1 did not show a significant difference between the pre- and post-tests. Consequently, we have to improve the quality of teaching the information regarding these questions.

Question 6: Assuming sending email to the following address.

To: Bob

CC: Carol, Dyane, Emma

BCC: Frank, Gabriel

Select the wrong statement.

Options:

Ans1: The address of Bob is disclosed to Carol.

Ans2: The address of Carol is disclosed to Dyane.

Ans3: The address of Dyane is disclosed to Emma.

Ans4: The address of Emma is disclosed to Frank.

Ans5: The address of Frank is disclosed to Gabriel.

Figure 2 : Question 6 (Part 3): Understanding the meaning of BCC and CC

Question 1: Select the incorrect statement regarding the file whose extension is .exe.

Options:

Ans1: The program for installing software on the computer.

Ans2: If you double-click the file, the program is executed.

Ans3: The virus-infected program.

Ans4: You should not execute the file whose extension is .exe.

Ans5: If you download the file whose extension is .exe, you should confirm where it came from.

Figure 3 : Question 1 (Part 1): The file whose extension is .exe

Question 20 is relevant to sending a message without including the senders' identities. This result affected the performance of "S" in both 2009 and 2010. The correct answer rates of the pre- and post-tests of "S" in 2009 were 45% and 62%, respectively, and 38% and 49% in 2010. Smartphones were starting to come out at this time, and when people sent an email using a smartphone or a mobile phone, they did not write their identities (name, affiliation, etc.) because it was easy to identify who the email was from if the address of the sender was registered. Therefore, it was no longer necessary for senders to write their identities explicitly. However, identities are necessary when using traditional email.

The overall results also show that students tend not to understand the accurate definitions of some technical terms and lack net manners for sending email.

V. Conclusion

In this paper, we evaluated the competency levels for information literacy and information fluency of students who took a course in information literacy or information fluency during 2009–2011 and in 2014.

Moreover, this study used performance-based tasks to develop a direct measure of ICT competence.

Significant differences occurred between pre- and post-tests for all of the courses. These differences indicate that the students' skill improved through the courses.

In addition, although year-to-year differences occurred, no overall trend was seen.

For the mixed-year courses, no difference occurred between school years.

The result of the investigation about fields difficult for students to understand revealed that students tend not to understand the accurate definitions of some technical terms and lack the net manners for sending email.

This research did not clarify whether a student-centered style or a teacher-centered style is better. However, a blended style is efficient when considering the outcome of this research.

Beginning in 2013, taking a course on information studies became a requirement for all newly admitted high school students in Japan. Therefore, it will be necessary to investigate whether the performance of these students improves after several years. In addition, because the pre- and post-tests used in this research might not cover all aspects of the essential knowledge about information literacy and information fluency, they should be refined in the future.

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Key points to remember:

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A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

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What to keep away from

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The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

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- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
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- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

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	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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