hazard especially for the field workers.

Pakistan's forests which presently occupy only 5.2% of the land area are shrinking by more than 1% per year due to fuelwood collection, human settlements and agricultural expansions. The construction of dams on the other hand has caused degradation of some 50% riverine forests beyond economic viability. In addition the reduced dilutory effect has resulted in low biodiversity in the mangrove areas (ODA, 1992) which are also being destroyed for fuelwood collection and by grazing animals (GOP - IUCN, 1992).

In Pakistan, 35% of the irrigated area suffers from problems of salinization and more than 40,000 ha of irrigated lands are lost each year to water logging and salinity (Middleton, 1995). Pakistan loses more than 60 million tonnes of fertile soil each year due to erosion caused by overgrazing, forest removal and cultivation on marginal lands (GOP - IUCN, 1992). The River Indus carries sediment load of 750 million tonnes per year, being fourth in the world in magnitude (Brown et al., 1996). Agricultural expansions, deforestation, monoculture afforestation, industrialization, hunting and poaching, on the other hand, have caused a serious loss to the country's biodiversity. As a result about 500 species of plants and animals are likely to be endangered in the near future.

5. ENVIRONMENTAL PROTECTION AND CONSERVATION

Although environmental degradation has drastically accelerated in the past three or four decades, concern about it is not a new phenomenon. In the past, many societies and groups focussed their attention on environmental problems, wilderness preservation and resource conservation (Miller, 1995). However, the early 1970s marked the period of greatest change in both the environmental movement and environmental politics. The following three conferences received worldwide recognition in this respect.

1. THE STOCKHOLM CONFERENCE (JUNE 5-16, 1972)

The U.N. Conference on the Human Environment was held in Stockholm in 1972. It was attended by delegations from 113 nations. The conference addressed the particular set of environmental problems identified by developed countries i.e., pollution, population explosion, conservation of resources.

The most tangible outcome of the Stockholm conference was the creation of the United Nation Environment Programme (UNEP). It was also decided that June 5 was to be celebrated every year as World Environment Day.

2. MONTREAL PROTOCOL

The Montreal Protocol on substances that deplete the ozone layer was signed in September, 1987. It was initiated by UNEP. The group countries indicated a willingness to freeze the production of CFCs and halons by 50 percent by 1998. Then in July, 1990, more than 90 countries signed the agreement in London to phase out all use of CFCs by 2000. Many developing countries signed the protocol because the industrialized countries agreed to transfer alternative technologies and provide adequate financial assistance for phasing out CFCs. The Montreal Protocol has so far been ratified by 127 parties.

3. THE EARTH SUMMIT (JUNE 3-14, 1992)

World leaders from over 170 countries attended the United Nations Conference on Environment and Development (UNCED), commonly known as Earth Summit held at Rio De Janeiro, Brazil, to pave the way for establishing a new world environment order. The following four agreements were signed by the countries present at the conference.

i. Rio Declaration (Earth Charter, 1992).

The 27 point declaration pledges global commitment to:

- Eradication of poverty
- Promotion of sustainable development

- Protection of environment
- Sustainable use of earth resources.

The declaration has no legal binding force.

ii) Convention on Climatic Change

It was signed by 154 countries. The objective of this treaty is to prevent global warming by putting cuts on CO_2 and other greenhouse gases emissions.

iii) Biodiversity Convention

It is an effort to protect planet species and habitat. The convention on biodiversity reaffirms the sovereign right of the countries to use, manage and control their biological and genetic resources including forests.

iv) Agenda - 21

It is the U.N. Programme of Action on Environment and Development. It provides guidelines to 180 nations of the U.N. for:

- Protection of forests
- Biological diversity
- Management and use of water resources
- Activities affecting global warming and climatic change.

Agenda - 21 further emphasized the need for an effective Environmental Impact Assessment (EIA) process. EIA has emerged as one of the most valuable tools for sound environmental management.

Efforts have also been made to propose environmental conservation strategies at international and national levels. In this context, it would be appropriate to mention the followings.

i) World Conservation Strategy

To help advance the achievements of sustainable development through the conservation of living resources, the International Union for Conservation of Nature and Natural Resources (IUCN) with the assistance from UNEP, WWF and FAO formulated the World Conservation Strategy in 1980. The objectives of the strategy are the maintenance of essential ecological processes and life support systems, preservation of genetic diversity and sustainable utilization of species and ecosystems.

ii) The Pakistan Environmental Protection Ordinance

To control the increasing environmental pollution in the country, the Pakistan Environmental Protection Ordinance was promulgated in December, 1983, and later revised in 1997.

Under the provision of the Ordinance, the Pakistan Environmental Protection Council has been established for framing national environmental policy and overseeing its implementation. Under the provisions of the Ordinance, Environmental Protection Agencies (EPAs) have been created both at federal and provincial levels. National Environmental Quality Standards (NEQS) have been enforced since July, 1996.

iii) National Conservation Strategy (NCS)

In March, 1992, the Government of Pakistan endorsed the National Conservation Strategy (GOP - IUCN, 1992) to ensure that the country's future development is undertaken within the context of a national environmental plan. The strategy has three main objectives: conservation of natural resources, sustainable development and improved efficiency in the management of resources.

6. THE LINE OF ACTION

For sustainable development and environmental protection of the planet, the issue of the greatest concern is that of population explosion. It is utmost necessary that population stability is achieved throughout the world. To this effect, there is need for sustained worldwide attention to the issue and increased international assistance for family planning services. Other factors to help control population would include girls' education, higher marriage age and working opportunities for women. There is also strong need to alleviate poverty and illiteracy in developing countries. For the two reasons, these countries are unable to manage their natural resources and forced to exploit them beyond sustainable limits. Since developed countries are the major consumers of the earth's resources, it is in their own interest to assist the developing countries to overcome these constraints. If the world has to progress in a true sense, inequalities based on poverty and illiteracy will have to be removed. Poverty can be eliminated through economic growth. Direct development targeted to the very poor would be of fundamental importance in this regard. To alleviate poverty, would therefore require fostering rural development in general and smallholder agriculture in particular (Serageldin, 1996). There is also a substantial evidence that individuals' education is closely linked to their incomes. In this context, education of girls may not only lower fertility rates but also help alleviate poverty through employment opportunities.

There is in general inadequate productivity in much of the world and many developing countries are in serious need of additional food. To increase productivity soils must be conserved and desertification minimized. To achieve sustainable development, therefore, good landuse planning and improved farming practices are required. Plans for sustainable forms of agriculture should be developed and implemented. Reclamation of soils that have been badly eroded may be tried by providing plant cover and through restricted landuse to restore soil fertility. Increasing the efficiency of irrigation and improving the management of rural resources should form the integral part of the policy programme to enhance food productivity.

Efforts must be made to conserve limiting supplies of water. In this context recycling and reuse of effluents be given priority. To combat water pollution, wastewaters must be adequately treated before their discharge into the receiving water bodies. Environmental degradation can be minimized through adequate gaseous emission control, appropriate solids and hazardous waste management and preventing the introduction of harmful substances into the environment. Developing countries need to initiate monitoring programmes for ambient air and water resources to build database for sound environmental management. In addition, environmental impact assessment must be carried out for all development projects.

The most serious long term global problem appears to be the loss of biodiversity. Industrialized nations will be the worst affected by species extinction as much of their prosperity is grounded in biodiversity. To save endangered species, their habitat must be saved. There is need to strengthen the tropical countries, technically and financially, in the use of biodiversity as a source of unique genes for genetic engineering. Through biotechnology the agricultural and forestry systems can be improved. As such, a global effort should be made to improve traditional crops and develop new ones in areas not under cultivation.

At present, global warming elicits a high value of concern. The challenge can be met by cutting down the emissions of greenhouse gases into the atmosphere through reducing reliance on fossil fuels, shifting to solar energy and hydlepower and halting deforestation. To discourage CO2 emissions, a carbon tax paid on fuel consumption may be considered by the developed countries. To reduce deforestation, sustainable management of forests and launching of afforestation programmes must receive high priority. In addition low intensity harvesting of crops should be encouraged in cleared forests.

To save the thinning ozone layer, production of CFCs must be seized by the year 2000 and efforts fortified to search for environmentally safe substitutes. To prevent acid rains, there is need to implement a comprehensive energy plan. Such rains can be minimized by restricting the use of sulfur rich coal. To enable developing countries employ scrubbers to remove SO2 emissions from coal burning, developed countries should share in paying for it. This is necessary for the security of the environment in developed countries as such emissions know no boundaries. Regional cooperation, in general, will be needed to solve many air and water pollution problems.

In the interest of the human health, reliance on pesticides in agricultural practices will have to be cut down through integrated pest management programmes and by employing biological pest control techniques. Likewise, through genetic technology efforts will have to be made to reduce the use of nitrate fertilizers.

Above all, 'to love the mother earth' should become the way of life for the human race. The realization of that love is to conserve natural resources, save on energy, plant trees, cut down on production of wastes and avoid polluting the environment.

7. SUMMARY

1. Environment includes human beings, plants, air, land, water, animals etc., mutually interacting. Physical environment consists of living and nonliving things which interact with each other to form different ecosystems.

2. Natural resources of the earth may be classified as continuous, non-renewable and renewable. When the renewable resources are consumed at a rate faster than their replenishment, the process is known as environmental degradation.

3. Human environment includes all aspects of human species, their skills, abilities and institutions. All environmental problems are the result of a mismatch between human resources and natural resources.

4. Rapid increase in human population, urbanization and industrialization have resulted in over-exploitation and misuse of natural resources. There are clear imbalances between richer and poor nations on the use of these resources. Poverty has emerged as a major polluter of the environment.

5. Due to human activities, carrying capacity of the ecosystems has been exceeded and the environmental degradation is reaching alarming levels. Many environmental issues such as population growth, desertification, soil erosion, deforestation, global warming, ozone depletion, loss of biodiversity and water, air and land pollution are very serious and require urgent attention.

6. The Stockholm Conference on the Human Environment, the Montreal Protocol, the Earth Summit and other conventions are indicative of the efforts being made at the global level for the protection of the environment.

7. Pakistan through Environmental Protection Ordinance and the National Conservation Strategy is endeavouring to protect the environment and conserve natural resources of the country.

8. Many measures are available for the protection and conservation of the environment. For their effective implementation, however, the developing countries would need technical and financial assistance from the developed ones. On global scale, humans must change their attitudes towards indiscriminate use of natural resources and better adopt a life style which promotes savings on energy, a cut on production of wastes and avoidance of environmental pollution.

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IMPLICATIONS OF HEAVY VEHICLES FOR ROAD PAVEMENTS

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INTRODUCTION:

That a heavy lorry causes more damage to a road pavement than a small one has long been known. Quantitative evidence of this, however, became available after the WASHO and AASHO Road Tests. These tests indicated that the amount of damage done to a road pavement is not only a function of the cumulative number of axle loads applied, but is also a power function of the magnitude of the axle loads.

Goods vehicles in Pakistan are generally over loaded and such an overloading is said to be one of the main causes of deterioration to its road network. By the very nature of our scarcity of resources and lagging economic status, we are compelled to husband our resources in the economically most careful manner. This particularly applies to road transportation both because of the immense capital, public and private, invested in this sector and because of the importance of efficient transportation for economic development.

The Road freight system may be considered roughly to contain two sub systems namely, road construction and maintenance, normally provided and run by public authority, and the road haulage, to a large extent operated by independent, public or private operators. But these two sub-systems are at odd in some important respects. While the road authorities role obviously is to provide road for vehicles to use, they also wish to do so at the lowest possible cost. The traditional solution to the problem, which has been adopted world wide is the imposition of legal axle-load and dimensional limits - such limits in most cases having been established as comp-romise between the demands of the two sub-systems.

This paper first describes the vehicle load spectrum and then effects of vehicle loads. The cases for limiting as well as increasing axle load and establishing the legal axle load limits in the context of developing countries like Pakistan have been discussed. The enforcement and the economic implications of over loading have also been examined at the end.

2. *AXLE LOADING*

2.1 Axle Equivalency.

The damage that vehicles do to a road depends very strongly on the axle loads of the vehicles. For pavement design purposes the damaging power of axle is related to a standard axle of 8160 kg. (8.16 tonnes) using equivalence factors which have been derived from empirical studies (Highway Research Board (1962), Paterson (1987). In order to determine the cumulative axle load damage that a pavement must sustain during its design life it is necessary to express the total number of heavy vehicles that will use the road over this period in terms of cumulative number of equivalent standard axles.

Equivalency factor for

$$\text{Li kg} = \left(\frac{Li}{8160}\right)^{A} \text{ ..... (1)}$$

Where A is an exponent dependent on road type and Li is the axle load in Kg. This relationship between axle load and the damage caused per load application was developed from AASHO road Test and was represented by Fourth Power Law. Although several authors have ana-

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lyzed the data form the AASHO Road test, the work of Liddle is widely accepted and the equivalency factors adopted for pavement design in tropical developing countries are based on Liddle`s analysis, which suggests a value of 4.55 for the exponent in equation (I). This value was derived by fitting a curve to a family of curves produced by Liddle for single axles on pavements with a range of strength and assuming terminal conditions similar to those commonly found in developing countries (Fig .... 1)

In the AASHO Road Test the maximum axle loads used were 13.6 tonnes for single axles and 21.8 tonnes for the tandem axle sets. Axle loads in developing countries are frequently above 20 tonnes according to recent surveys. It has therefore, been necessary to extrapolate beyond the AASHO Test.

2.1.1 Alternative Damage Relations from AASHO Data.

The fourth power law was derived form results obtained by trafficking different pavements to failure independently with wheel load of different magnitude. On a real road, however, failure is brought about by a wide spectrum of wheel loads applied virtually at random. Damage relations have been derived for three pavements representative of a wide Range of pavement strength (strong, medium and weak), when trafficked by one of three different traffic spectra representing that of an important arterial traffic route, a major road and a more lightly trafficked one. The results do not necessarily follow a simple power law throughout the practical load range. In table 2, the exponent of the power law operating at a given wheel load is given for 40 KN, the base wheel load of the AASHO Road for 65 KN, the maximum single axle load limit in use in OECD Countries, for 80 KN, representing a considerable degree of over load and finally for a much smaller 20 KN load, typical of those applied by small commercial vehicles.

Exponents on given pavement are not influenced appreciably by the load spectrum applied. In general fourth power is reasonable approximation for strong pavements, but in all cases exponents are greater than four for wheel loads at and above present legal limits. There are large differences between pavements of different strengths with much higher exponents on weaker pavements and under heavier loads. These higher values of exponent are to be expected on common sense ground, of similar but much less marked effect was noted in relation to pavements strength in the standard (Liddle`s) analysis of the AASHO results.

2.2 Axle Load Surveys.

Axle loads are one of the two principal factors determining the pavement design. Axle load surveys must therefore be carried out to determine the axle load distribution of a sample of the heavy vehicles using the road. Data collected from these surveys are used to calculate the mean number of equivalent standard axles for a typical vehicle in each case. These values are then used in conjunction with traffic forecasts to determine the predicted cumulative equivalent standard axles that the road will carry over its design life.

2.2.1 Determination of Cumulative Equivalent Standard Axles.

The equivalence factors for each of the wheel loads measured during the axle load survey are determined using Table 1. or the accompanyingequation to obtain the equivalence factors for vehicle axles. The factors for the axles are totaled to give the equivalence factors for each of the vehicles. For vehicles with multiple axles i.e. tandom, triples etc, each axle in the multiple group is considered separately. The mean equivalence factor for each type or class of vehicles traveling in each direction can then be determined by summing the equivalence factors for all of the vehicles in each class and dividing by the numbers of vehicles in that class. Vehicle classes are usually defined by the number and type of axles.

In order to determine the cumulative equivalent standard axles over the design life of the road, the following procedure is adopted.

I. Determine the daily traffic flow for each class of vehicle weighed using the results of the traffic survey.

II. Determine the average daily one directional traffic flow for each class of vehicle.

III. Make a forecast of the one directional traffic flow for each class of vehicles to determine the total traffic in each class that will travel over each lane during the design life.

IV. Determine the mean equivalence factor for each direction from the results of this axle load survey.

V. The product of the cumulative one directional traffic flow over the design life and the mean equivalence factor for each class of vehicle should then be calculated and added together to give the cumulative equivalent standard axle loading to be used in the design.

2.2.2 Axle load Surveys Carried Out in Pakistan.

In Pakistan, a county wide survey of Axle loads was carried out by NTRC for a period of one year form May 1981 to April 1982 at 35 points selected on main roads across the country. On the basis of the survey, the damaging effect of goods vehicles in different load classes observed works out as per Table 3 (applying the 4.5th power rule.)

It would reveal that one fourth of the vehicles not over loaded (including vehicles upto 9 tonnes, not considered as such) cause only 6.4% damage, 42% vehicles with rear axle loads upto 10 tonnes cause 16.7% damage. On the other extreme, 3.4% vehicles with rear axle load exceeding 13 tons cause 11.5% damage, 13% vehicles in load class 12 tonnes and over cause 32 % damage. Each loaded vehicles is equal to 3.3 equivalent standard axles.

Besides, National Highway Board also had load surveys carried out through M/S ACE and REC for the improvement and design of the existing Indus Highway (Kashmore- D.G.Khan - D.I.Khan section in June/July 1987).

Road Research and Material Testing Institute, Lahore has more recently carried out Loadometer studies on the following roads in Punjab:-

I. Faisalabad - Shah Kot Road

II. Faisalabad - Samundry Road

III. Faisalabad Jhang Road

IV. Lahore - Multan Road

V. Lahore - Sheikhupra Road etc.

From the comparison of studies by various agencies in Pakistan it is evidently clear that the equivalent standard axles per goods vehicles are much higher in Pakistan than those recommended by AASHO Interim Guide and the British Road Note 29 as shown in Table 4. Consequently adoption of AASHO Interim Guide/Road Note 29 equivalence factors resulted in under designing of roads in Pakistan. There is, therefore, need to adopt appropriate design factors for pavement design. Road Research and Material Testing Institute, Lahore has accordingly recommended equivalence factors for Pakistan which are indicated in table 5. It may however be noted that the above studies are either incomplete or do not circumscribe the whole spectrum of commercial vehicles. Because of limited data base, extensive axle load surveys are imperative for accuracy of results. Nevertheless, despite their in-herent limitations, a facet of all the surveys is that a minority of the total commercial flow induces a disproportionate share of the pavement damage.

3. OVER LOADING

The legal axle load limit under rule 216 of the Motor Vehicle Rules 1969 is 8 tonnes in Pakistan. More recently, the Provincial Transport Authority of Punjab has reportedly relaxed these rules in view of the introduction of heavier trucks of HINO and NISSAN makes, their rear axle loads being 10 tonnes and 12.4 tonnes respectively. While legality of this relaxation is yet to be ascertained on rational grounds, tendency of over loading beyond these limits is exceedingly manifest. From table 3 (NTRC) even if vehicles upto 9 tonnes rear axle load are not classified as over loaded, there will still be 75% vehicles over loaded. The later studies by ACE and Road Research Institute, Lahore have shown still more excessive loading and in certain categories the rear axle load is even more than 20 tonnes. It appears that the roads are free for all and there is absolutely no check on the axle loads / over loading.

4. THE CASE FOR LIMITING AXLE LOADS.

The road surface constitutes the contact area between the pavement phase and the vehicle phase. As such, its characteristics take on a particular importance. On the one hand, the road surface condition is reflection on the structural performance of the pavement as the road is "Hammered" by the traffic, deterioration occurs in the pavement components, which is manifested in cracking, rutting and roughness of the pavement surface. On the other hand, the surface condition particularly roughness and rutting has direct influence on the vehicle operating costs.

Road deterioration at any location, where environmental factors are given is essentially a function of the pavement strength and traffic (volume and axle load distribution). The power of a vehicle to damage a road is related to its axle load. Thus equation 1 (Para 2.1) implies that a 17% increase in load, about doubles the inflicted pavement damage.

There have been only few attempts at verifying the validity of the AASHO results to roads in developing countries, where the climate, environment, soil types, pavements compositions and stiffness and other factors are very different from those where the road test was carried out.

Besides the roads in developing countries are not built to so high structural specifications as in the Road Test. Thus exponent 4.5 may be higher for weaker pavement.

Whatever exponent one should realistically adopt, the damaging effect of the very high axle loads is tremendous. Having defined road performance criteria, particularly the surface condition, one may intervene at various stages, be it with resurfacing, asphalt overlay of full rehabilitation to prolong or renew the road "service life". The extent and timing of action may be decided on a subjective basis, which to a large extent may depend on what the travelling public is "Prepared to accept". Or it may be done on an economically objective basis, to that extent one is now able to model and simulate the road vehicle inter action and derive the total system costs, where by the economic consequences of various maintenance policies may be evaluated. For bridges, however, the approach is different i.e. because the most critical members of bridges - beams and girders are designed for total "trains" of vehicles, rather than singular axle loads, and the failure of a bridge due to a particular over loading is catastrophic and irrevocable as compared to a road pavement.

In Pakistan, the tendency for overloading is great, both because of the nature of the haulage and because of slack or non-existing axle load limit enforcement. In addition, road maintenance is inadequate. In many instances, the over all traffic volume is relatively low and funds are scarce, leading to a relatively light design. Consequently deterioration with traffic is rapid.

5. THE CASE FOR INCREASING AXLE LOADS.

The vehicle operating costs include all the capital and running costs relating to vehicle operation. The economic costs in this context comprise fuel, tyres and tubes, vehicle maintenance and lubrication, driver wages, insurance, interest and depreciation. These are the costs which count when it comes to the economic analysis of public policies. However, the trucker is faced with additional costs, transfers in the economic sense, but very direct to him. These mainly comprise taxes and duties, the structure of which may have a significant. Effect on a trucker's strategy, e.g. in selection of truck type and size. This will effect his haulage tariffs, which may in turn have a significant effect on e.g. shippers choice of mode or rentability of production. Hence for assessing the response to a change in taxation or axle load limits or enforcement or whatever, the total financial costs facing the groups involved have to be included.

Variations in haulage costs will be considerable. Since they depend on several factors including vehicle size, pay load factor (carrying capacity V.S loaded gross weight), coefficient of utilization, type of haulage, road geometry, surface conditions, climatic conditions etc.

All these factors will be taken into account by the knowledgeable trucker, when deciding on truck size and loading policy. Given lax enforcement and adequate demand for transport in Pakistan he chooses the "heavy truck" so as to increase his revenue even without overloading his vehicle but well exceeding the legal load limit. To a large extent, the trucker should be influenced by the taxation policy. In this context, fuel tax, collected at the pump, is probably the most efficient method of tax collection. In many countries including Pakistan, the tax on diesel fuel predominantly used by large trucks is held very low compared to gasoline taxes. The economically more equitable measure would be to place on exponentially increasing tax (at registration and annually) on the larger, heavy axle vehicles, to reflect the damage they inflict on road pavements. However no country seems to have such a system in operation, although taxes often do increase, e.g. percentage-wise with the purchase price.

6. *ESTABLISHING THE LEGAL AXLE LOAD LIMITS*

We thus have the two opposing forces. The truckers pressing for higher axle load limits, to maximize their profits. The road authorities resisting, to preserve their investment and minimize maintenance costs. A third cost item that enters the picture, is the cost of enforcement of axle load limits by no means a negligible cost, and one that in many cases may render the strict enforcement of given limits more costly than carrying out road strengthenings obviously, the higher the legal weight limits, the less onerous the task of enforcement.

In principle, the establishment of legal vehicle weight, axle load and dimension limits, whether initially or by change of existing regulations, can, for economic efficiency, be established through incremental analysis. Here it should be kept in mind that the existing highway infrastructure of developing countries including Pakistan is, as a rule, poor (not only road pavements and bridges but also geometric design). Hence the introduction of larger trucks implies large incremental expenditures on infrastructure. Through incremental analysis, the economic effects of variations, be it increase or decrease of limits from a given situation, comparing "with" and "without" situation in a step-wise fashion, can be evaluated. Hence for each situation, total costs (including "disbenefits") to society of transport is evaluated and the regulations that would secure the lowest total cost would be instituted. Often the most economic solution in developing countries, due to the extreme scarcity of capital and low traffic volumes, may be lower axle limits and smaller vehicle dimensions.

While this frame works is theoretically simple and logical. its implementation in practice is fraught with difficulties. A major task is to measure or evaluate the axle weight distribution in the current situation, and what can be expected under a new set of axle weight regulations and enforcement programs. Obviously the degree of sophistication of the analysis will depend on the rich-ness of the data base. In a developing country, one shall in most cases have to make do with far far less quality and quantity of data. On the other hand, the extent of the road network , the types of goods carried, the traffic patterns by region and seasons and the number of vehicle types encountered, will frequently be simpler in a less developed country .

In the end, whether the legal limitation are based on an economic analysis, or in response to the various pressures at the political level, certain generalities prevail. For instance, all public roads, within a country or within a region, should as far as possible be subjected to the same limits.

Reviewing axle load limits in various countries over the years one will notice that there has been gradual increase, and some tendency towards a greater extent of agreement between countries. For instance the most common set of limits today, as published by the International Road Federation is 10 tonnes single/16 tonnes tandom, or minor variations of this and the maximum gross weight in general ranges from around 16 tonnes for 2 axle trucks to around 38 tonnes for large, articulated rigs.

In the Central American countries (except Panama) and Mexico, 8 or 9 tonnes is permitted for single axles. These limits are in line with the Pan-American Highway Congress Policy of 8 tonnes and the AASHTO policy of 1976, viz, 9.1 tonnes. In U.K. axle weight limit is 10 tonnes, whereas in most of other European countries, it is 13-tonnes. It is note worthy that inspite of economic pressure from European Economics community, UK did not enhance its axle load limit, also it would have to redesign its entire road network.

In developing countries, the difference in axle load limitations is noticeable, the most common figure being 8.2 tonnes single axle load limit.

Considering paucity of resources and rather poor road network in Pakistan and examples of other countries, it would perhaps be more appropriate to increase our axle load limit from 8 tonnes to 10.0 tonnes after necessary legislation.

7. *ENFORCEMENT*

At the outset, it should be clear that the enforcement of axle load and dimension limitations should be seen and done as part of the overall highway law enforcement system. Hence, the enforcement of the various aspects of the Highway laws should be under a single authority, where the various facets of control are coordinated and properly balanced. There is little hope of success, for instance in the sporadic enforcement of one aspect of the laws, in an ambience characterized by laxity and non-compliance and the rational behind passing any regulatory legislation should be the intent and ability to enforce it.

Many measures of enforcement can be carried out without a need to do actual weighings, still many of them related to, and will enhance the control of axle loading:

I. Control of vehicle specifications on import or manufacture: import of vehicles with load capacity for in excess of what is indicated by permissible axle loads, should be prohibited. On the other hand, the vehicles have to meet safety standards, e.g. they have to have an adequate power / weight ratio to meet gradeability and acceleration requirements when fully loaded, the maximum load permitted on the vehicle, should be clearly displayed.

II. Control of vehicle modifications: such modifications are frequently done to gain greater carrying capacity. Wittingly or unwittingly such modifications may neglect engineering and safety requirements in design and workmanship and may cause increased damage to the pavement. Hence clear guideline for the manufacture and an adequate inspection system need to be ensured.

8. ECONOMIC IMPLICATIONS OF OVER LOADING.

In a study carried out by NTRC in 1983/1984 it was concluded that it was economical to build stronger roads and to strengthen the existing roads rather than imposing restrictions on loads in Pakistan. It was further concluded that pavement costs increase marginally with increase in axle loads.

It appears that the damaging effect of over loading has been under estimated in this analysis due to limited data base. On the one hand it is contended that the road net work has low specifications. On the other hand, it is stated that increase in load is justified, while the sources are scarce. This may perhaps not be realistic conclusion.

This study was based on axle weight survey carried out in 1982. There have been more recent axle load surveys as narrated in foregoing paras. The vehicle load spectrum and the equivalence factors derived therefrom would suggest serious implications of the very heavy axle loads plying on our roads in the absence of any enforcement. When the developed countries do not find it appropriate to enhance their axle load limits, given rich data base, good road net work and adequate resources, how can a developing country like Pakistan can afford not to impose restrictions on axle loading. It may also not be appropriate to say that pavement costs increase marginally with increase in axle loads. If the pavements / overlays are designed taking into account rational equivalency factors and other parameters, the costs of new construction / strengthening would be appreciable.

It would, therefore, be all the more important to standardize the heavy vehicles and impose load restrictions in addition to adequately strengthening the road net work in Pakistan.

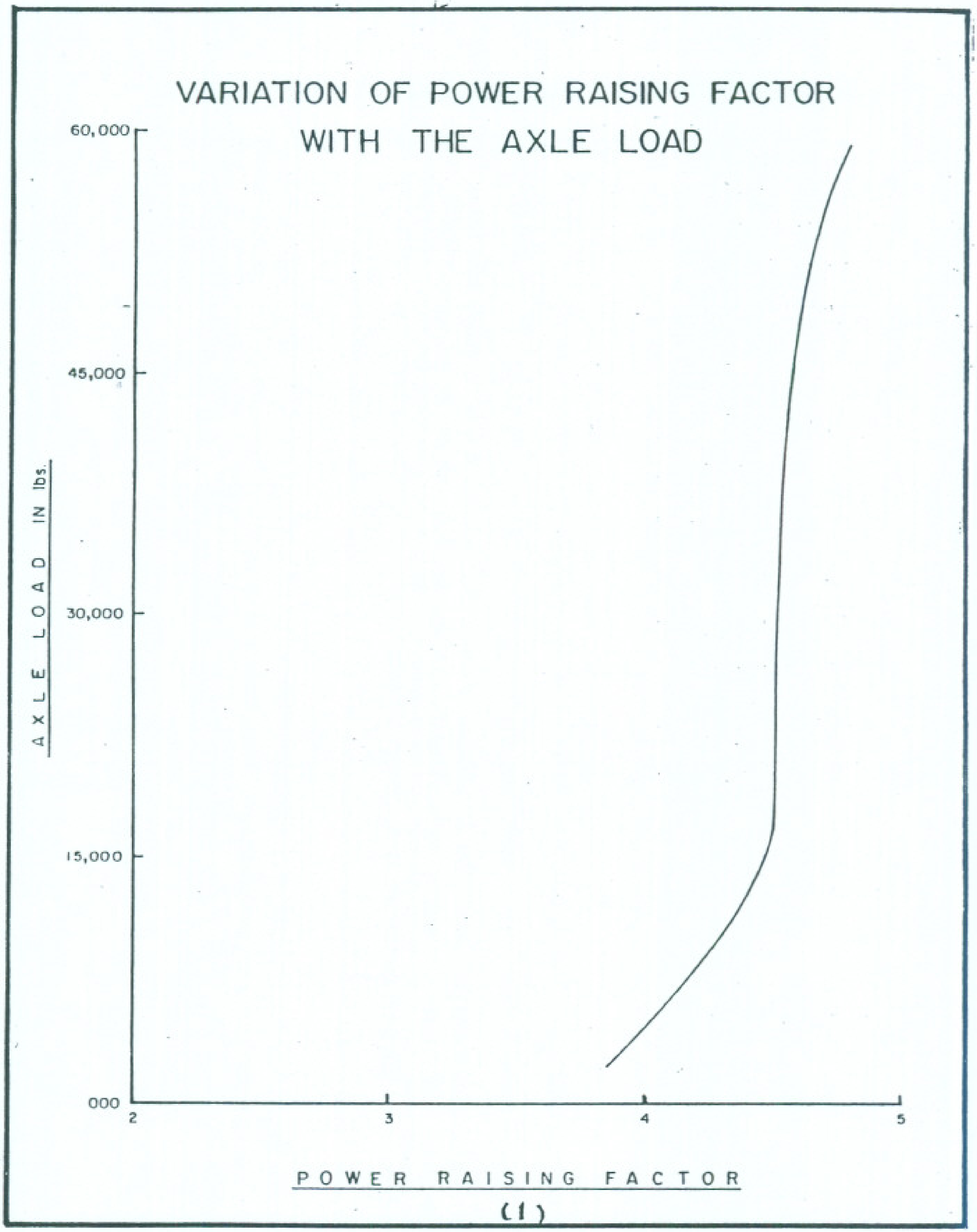
The vehicle load spectrum and the equivalence factors derived therefrom would suggest serious implications of the very heavy axle loads plying on our roads in the absence of any enforcement. When the developed countries do not find it appropriate to enhance their axle load limits, given rich data base, good road net work and adequate resources, how can a developing country like Pakistan can afford not to impose restrictions on axle loading. It may also not be appropriate to say that pavement costs increase marginally with increase in axle loads.

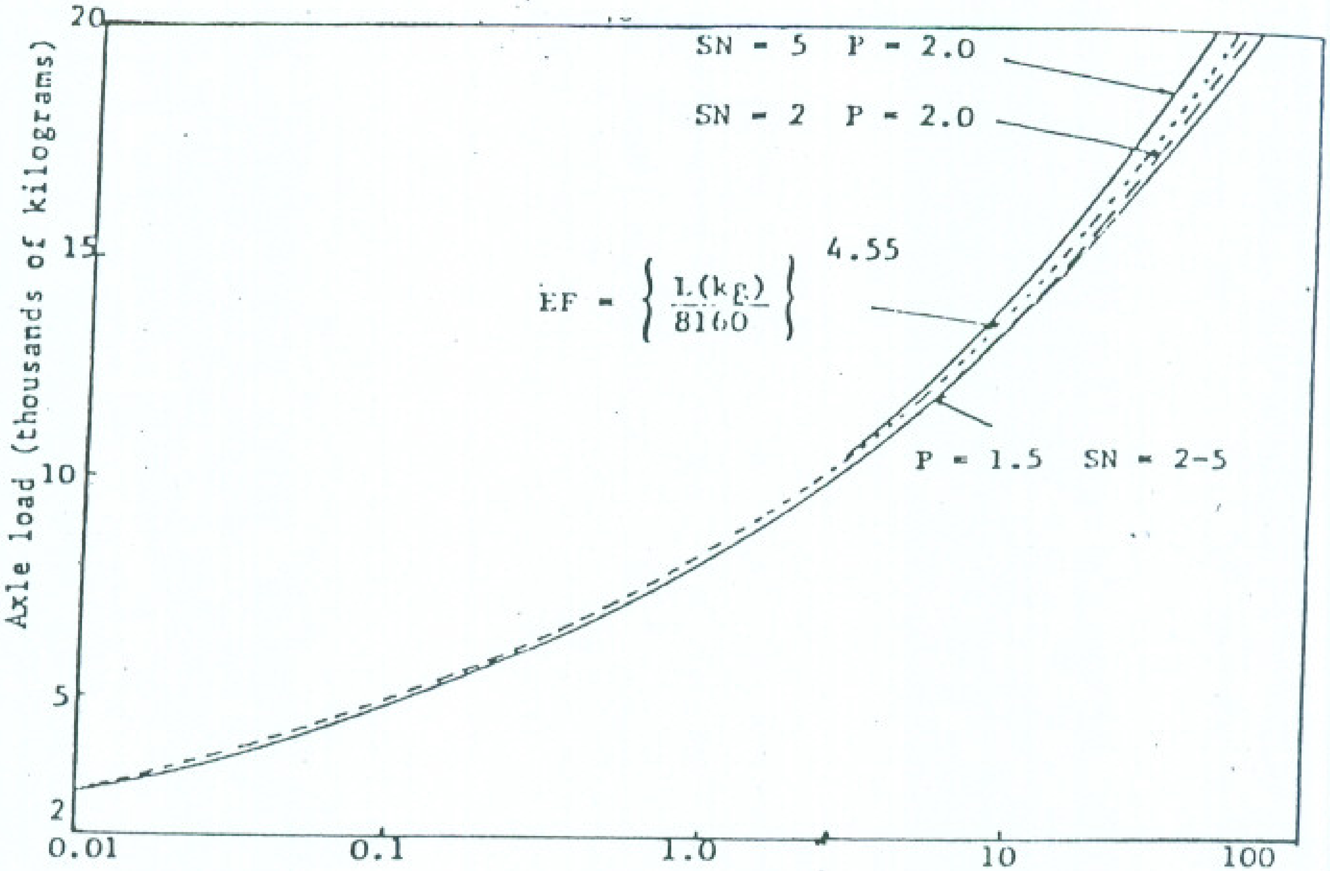
9. CONCLUSIONS

The damaging effect of the very heavy axles to pavement is tremendous. Although, it is assumed to vary exponentially to the power 4.5 for the purposes of pavement design, yet this exponent may be higher on weak pavements under heavy loads encountered in developing countries like Pakistan.

The recent axle load surveys, though sample, carried out in Pakistan suggest significantly high equivalent standard axles per goods vehicle. Extensive axle load survey, however, need be carried out on roads across the entire country to determine the actual vehicle load spectrum.

There is acute over load problem in Pakistan and there is virtually no enforcement of legal axle weight limit. The road network is poor and the resources are scarce. There is, therefore, dire need to standardize heavy vehicles and to impose load restrictions in addition to adequately strengthening the existing roads.


VARIATION OF POWER RAISING FACTOR
WITH THE AXLE LOAD
60,000
45,000
30,000
15,000
000
AXLE LOAD IN lbs.
2
3
4
5
POWER RAISING FACTOR
(f)



P = terminal condition of pavement in terms of its present serviceability (2)

SN = pavement strength defined by structural number (2)

Fig. 1 EQUIVALENCE FACTORS FOR SINGLE AXLES

When you think of Allah's blessings and favours showered on you be sincerely thankful and when you think of your own shortcommings and errors sincerely seek His forgiveness.

Wasif Ali Wasif

TABLE 1

Equivalence factors for different axle loads

Wheel Load (kg)	Axle Load (kg)	Equivalence Factor
1500	3000	0.01
2000	4000	0.04
2500	5000	0.11
3000	6000	0.25
3500	7000	0.50
4000	8000	0.91
4500	9000	1.55
5000	10000	2.50
5500	11000	3.83
6000	12000	5.67
6500	13000	8.13
7000	14000	11.3
7500	15000	15.5
8000	16000	20.7
8500	17000	27.2
9000	18000	35.2
9500	19000	44.9
10000	20000	56.5

Equivalence factor = $(\text{Axle load in tonnes}/8.16)^{4.55}$

TABLE 2

Power-law exponents derived from an incremental damage analysis of the results of the AASHO Road Test.

Pavement Type	Traffic spectrum	Exponent of Power law relating to wheel loads (kn) of			
		20	40	65	80
Strong	medium	3.8	3.9	5.0	5.2
	heavy	3.8	3.5	4.3	5.2
Medium	light	3.1	4.0	8.3	-
	medium	2.8	3.1	5.4	8.2
	heavy	2.3	2.6	5.1	7.7
Weak	light	2.5	6.0	6.7	-
	medium	1.2	5.7	8.1	11.6
	heavy	-	5.4	7.4	7.6

TABLE 3

DAMAGING EFFECT OF GOODS VEHICLE

Rear Axle Load (tons)	*% of Vehicle*	*Equivalent Factor*	*Damaging Effect*	*% Damage*
Upto 6.9	7.4	.47	3.47	1.1
7-7.9	6.0	.68	4.09	1.2
8-8.9	11.4	1.20	13.66	4.1
9-9.9	17.3	1.98	34.20	10.3
10-10.9	23.7	3.10	73.50	22.2
11-11.9	20.8	4.67	97.14	29.4
12-12.9	10.0	6.80	67.97	20.6
13-13.9	2.4	9.61	23.16	7.0
14 & over	1.0	13.25	13.25	4.0
	100.0		330.44	100.0

Equivalent Standard Axles per vehicle = 3.3

TABLE 4

Comparison of Equivalent Standard.
Axles per vehicle with Different Sources.

S. No.	*Source.*	*Eq. Standard Axles Per goods vehicles.*
1.	AASHO Interim Guide.	0.58
2.	Road Note 29 (British)	
	Motorways designed to carry over 1000 vehicles per day.	1.08
	Roads designed to carry 25-1000 vehicle per day.	0.72
	All other public roads.	0.45
3.	Pakistan Axle load Surveys.	
	* NTRC	3.30
	** ACE	3.37
	***NHB	4.956
	**** RR&MTI	6.03

* National Transport Research Centre.

** Associated Consulting Engineers.

*** National Highway Board.

**** Road Research and Material Testing Institute, Lahore.

My proof convinces the ignorant, and the wise man's proof convinces me. But whose reasoning falls between wisdom and Ignorance, I neither can convince him, nor can he convince me.

Kahlil Gibran

TABLE 5

Recommended Axle Equivalent Factors for Vehicles in Pakistan.

Type of Vehicle.	*Eq: Axle Factor.*	*Source of Studies.*	*Code.*
Buses	0.635	NHB	1.2
2-Axle Trucks (Empty)	0.12	NTRC	1.2
2-Axle Trucks (Loaded)	6.03	RR&MTI	1.2
3-Axle Trucks (Empty)	0.10	ACE	1.22
3-Axle Trucks (Loaded)	24.82	RR&MTI	1.22
4-Axle Trailor Unit (Empty)	0.979	NHB	1.2.22
4-Axle Trailor Unit (Loaded)	26.466	RR&MTI	1.2.22
4-Axle Double Truck (Empty)	0.206	NHB	1.2.22
4-Axle Double Truck (:Loaded)	9.68	RR&MTI	1.2.22
5-Axle Trailor Unit (Empty)	0.597	NHB	1.2.222
5-Axle Trailor Unit (Loaded)	12.64	RR&MTI	1.2.222
6-Axle Trailor Unit (Empty)	0.597	NHB	1.22.222
6-Axle Trailor Unit (Loaded)	9.041	NHB	1.22.222
Trailor Agriculture	0.005	NHB	-
1-Axle Trailor Trolley	2.26	RR&MTI	1+1+1
2-Axle Trailor Trolley	3.45	NHB	1+1+2

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Do look up to the sky, but do not forget that you are walking, down on earth.

Wasif Ali Wasif

SUGAR INDUSTRY IN PAKISTAN AN OVERVIEW.

Engr. M. Nawaz

There are about 75 sugar mills, now a days, in operation in Pakistan with the cane crushing capacity ranging from 1000 tpd to 10,000 tons each per day. If properly planned, these sugar mills should produce sugar not only to cater with local requirement but also to be exported to the neighbouring countries to earn heavy amounts of foreign exchange. Unluckily, due to a number of reasons, most of which are easily controlable, we have to import a lot of sugar every year spending heavy amounts of Foreign Exchange which, otherwise, could have been spent in other more important items / products.

Production of sugar at peak was 3 million tons during 1994-95 season when 316,000 tons sugar was also exported apart from meeting local demand but from then things have been worsening through counter productive steps taken by the Government like curbing credit facilities to the mill owners and high handedness of Government Agencies alleging the businessmen hoarding sugar and likewise disrupting the supply/demand cycle through their cruel and nasty steps and resultingly production had been varying from 2.5 - 2.7 million tons per year converting the country from a net exporter to a net importer one, wasting foreign exchange to the tune of US$ 120 millions and also depriving the state exchequer over Rs one billion in revenue from central excise duty. Rather if the conditions are made more favourable, incentives are given, sugar production could go upto 5.5 - 6.0 million tons per annum with the existing production facilities and accordingly Government revenue in the form of central excise duty and other levies could be increased substantially.

Sugar Technologists usually say that "Sugar is produced in the fields & only recovered from cane in the Mills". It is true but we have to see how much sugar is produced in the field & how much is recovered in the Mills. There is no proper method in practice to check the amount of sugar produced in the Fields due to which a lot of mistakes, ignorance, overlooks, & some blunders are committed in the darkness, thus putting all the blames on the cane.

There is no proper method in practice to check the amount of sugar produced in the Fields due to which a lot of mistakes, ignorance, overlooks, & some blunders are committed in the darkness, thus putting all the blames on the cane.

OBSERVATIONS & SUGGESTIONS

1. A fully equipped college of sugar Technology along with a Research centre should be established by the Government with the financial help of all the sugar Mills. This may be achieved by a reasonable share contributed by the mills on the basis of production of sugar.

2. A healthy competition of recovery, efficiency, and production to capacity ratio should be formulated and arranged between the sugar mills and incentives be given by the Government to the achievers.

3. Only qualified and professionally sound expert technical people should be appointed on the management posts and no post should be kept vacant that is presently practised resulting heavy losses in the long run.

4. Every sugar mill should be bound to appoint trainee staff i.e. engineers and sub-engineers of various

disciplines, electrical, mechanical, civil, chemical. This will be beneficial to the industry, to the country by producing skilled educated.

5. Concerned Government Departments, the proposed sugar technology college, PSMA, PSST, jointly, should be involved in the following struggle.

a) To increase the cane yield per unit area.

b) To sow only the better variety sugar-cane. New sugarcane varities be produced through research and development by the concerned scientists and experts.

c) To supply the cane preferably to the nearer sugar mills to reduce recovery losses.

d) To improve the recovery and efficiency of all the sugar mills in the best interest of the nation.

e) To introduce the latest technology & equipment based on computerised automation.

Every sugar mill should be bound to appoint trainee staff i.e. engineers and sub-engineers of various disciplines, electrical, mechanical, civil, chemical. This will be beneficial to the industry, to the country by producing skilled educated.

CONCLUSION:

There need be some body/Department in the country responsible to regulate and organise the operational affairs of the sugar mills and in the best interest of the nation and the mills to improve their performance.

In the last it is strongly recommended that instead of establishing any large capacity sugar mills, we have to go to mini sugar mills of capacity ranging from 100 - 1000 TCD, particularly in the smaller sugar cane pockets and the Govt. should give incentive in the shape of excise and other taxes, rebate, and also easy and low interest loans which will surely help to control the employment problem of the country.

A healthy competition of recovery, efficiency, and production to capacity ratio should be formulated and arranged between the sugar mills and incentives be given by the Government to the achievers.

*

Courtesy: Chemical and Petro Chemical News

T & D TECHNOLOGY

Electricity distributors focus on product quality, service

In a market-driven electricity business, quality of product and customer service become paramount for distributors to distinguish themselves

*Cate Jones

As has already accurred in many other industries, customer service and retention are taking center stage in the electricity business. While electricity companies everywhere pay lip service to this trend, those in countries with highly developed bulk-power and distribution grids are having to put customer service in practice, because governments are encouraging less monopolistic and more market-oriented practices at the customer end of the meter.

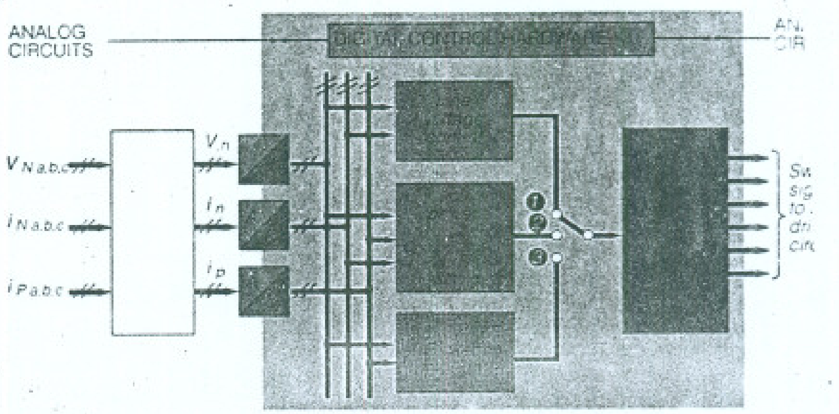


fig-1

Today, electricity distributors must be concerned about the quality of the power supplied to the customer. And that concern must go beyond the large industrial loads. Technologies that automate distribution and allow communication with customers are being applied by the leading companies. Even traditional sources of customer angst, such as power outages caused by lightning, are being revisited-all in the interest of becoming a customer-driven, competitive business. Finally, distributors which survive must be sensitive to customer needs, such as by applying under-ground lines instead of overhead (see box).

QUALITY IS JOB ONE

Power qualities becoming one of the three parameters-the other being capital investment and operation/maintenance expenses -- utilities must focus on and take an opportunistic attitude towards. It is an important measure of concern for customers with a choice in supplier. It can also be an area a utility can work with its customer base to provide service, add a revenue stream, assist in regional economic development, and/or otherwise avoid negative publicity associated with unreliable service.

Several parameters characterize power quality from the customer's perspective:

* Contributing Editor, Electric Power International, USA.

- Constant voltage is required because every electric system is, by definition a constant voltage system. Consider the proportion between voltage and electric torque in motors and it is easy to understand that even small voltage changes can be disruptive, even dangerous, for the customer.

- Constant waveform is generally measured with the total harmonic distortion. Harmonics create problems in rotating machines, static loads, and insulators. Many modern electrical loads produce more harmonics even as they are more sensitive to them.

- Frequency must be constant because its value directly influences mechanical parameters such as speed.

These parameters are now given the same stature as traditional measures of generating, transmission, and distribution assets--such as reliability and availability.

Microelectronic equipment--computers, cash registers, telecommunications devices, etc--are all sensitive to power quality. Additionally, an increasing number of new industrial equipment and household appliances are based on power electronic technologies. Almost everything, in other words, comes with a microcomputer chip that is integral to the mechanical or physical equipment.

Ironically, the very equipment that is most sensitive to power quality also presents a nonlinear load characteristic to the network, resulting in harmonics. Other types of line voltage distortions are flicker, caused, for example, by welding machines; unsymmetrical voltage, caused by unbalanced loading; and voltage fluctuations, which occur when capacitor banks or large loads are switched.

In sum, power-quality problems may be broadly classified into two categories: (1) non-ideal network supply voltages which affect load performance, and (2) loads which draw non-active current components (fundamental and harmonic frequencies) leading to voltage distortion at other feeders.

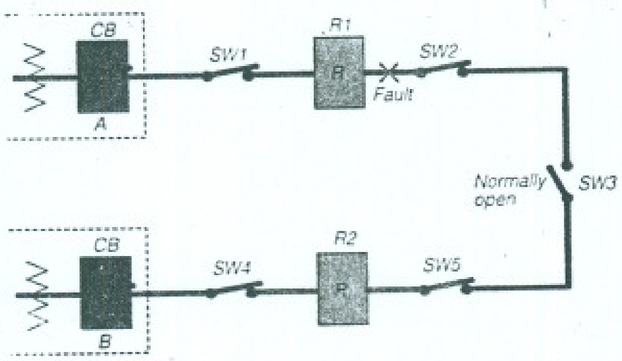


fig-2

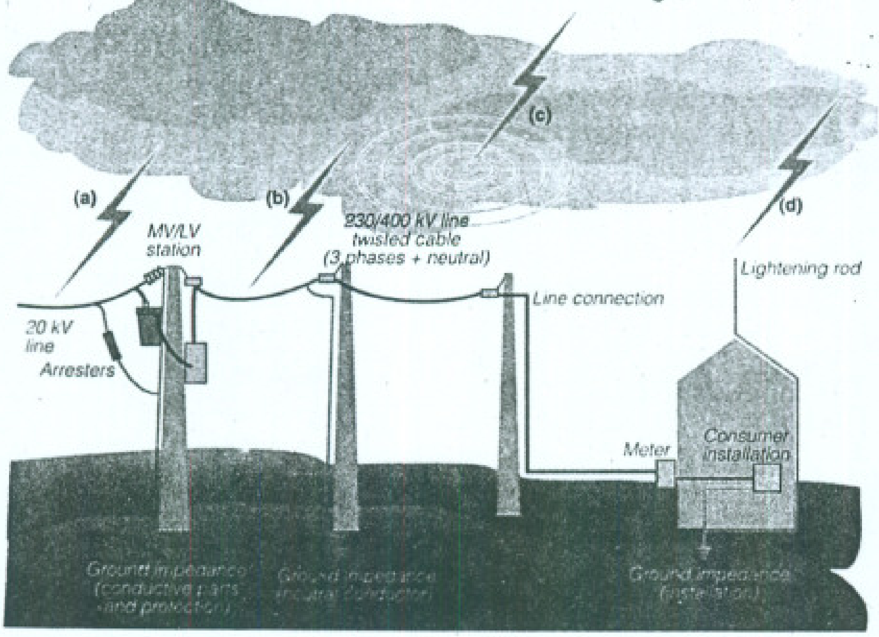
POWER CONDITIONERS

The increasingly complex requirements for the quality of electrical supply can not always be managed with conventional equipment. Power conditioners are a class of technology that has been developed to help solve these problems.

Representative of work in this area, Siemens AG, Erlangen, Germany, has developed a new system for improving power quality in low - and medium-voltage (LV.MV) distribution networks with more versatility than active filters. The two basic configurations--shunt connection and series connection--are analogous to flexible ac transmission systems (Facts) technology. The power conditioners can simultaneously solve several power quality problems such as reactive power, harmonics, unbalanced loading, voltage sags and swells, and flicker.

The principal components of the device is a pulse-width-modulated (PWM) insulated gate bipolar transistor converter. To minimize development costs, a mass-produced, standard industrial motor drive converter was chosen. To minimize switching noise at harmonics of the PWM switching frequency, a passive coupling filter is used to connect to the point of common coupling (PCC).

fig-3



Phase voltages and currents are transformed to a space-vector coordinate system by an analog measurement card. The space vector provides information on both the positive and negative sequence network quantities. Control is in both time and frequency domain, as appropriate. The same hardware is used for both series and shunt applications (Fig 1). A shunt-connected power conditioner is used to solve load current distortion problems, while the series-connected power conditioner is used for supply-voltage quality problems.

In general, the shunt-connected version optimizes the current flowing from a load into the network. It improves the network current by injecting current into the PCC. The injected current compensates undesirable components of the load current.

The series-connected version is coupled directly into the power flow via a transformer. The purpose is to compensate voltage distortion originating elsewhere in the supply network and to protect sensitive loads against voltage sags and swells. In this configuration, the total power flow of the load is transferred through the coupling transformer. The protection scheme of the converter must reflect this requirement.

OVERHEAD DA

Distribution automation (DA) is one result of information technology (IT) being applied to the power distribution network. It primarily consists of the extension of telecontrol and monitoring systems into primary and secondary substations, supported by supervisory control and data acquisition (Scada) systems.

Some degree of overhead DA has been a common trend for at least a decade. Distribution networks which are configured as normally open-loop power can restore power to the rest of the network from an alternative source once a faulted section is isolated. An economical way to accomplish this task is to introduce remotely controlled, pole-mounted DA switches. Thus, quality and continuity of service to the customer is greatly improved.

Two primary applications of switches are load switching and fault isolation. For load switching, parts of the feeder can be switched between substations to balance load, minimize line losses, and transfer emergency load when one substation experiences overload caused by peak conditions, loss of substation transformer, etc. In these relatively simple applications, switching decisions are made at the substation or central locations and simple open or close commands are issued to the switches. Current monitoring capabilities at these switches helps describe the loads at various parts of the feeder.

Increased demands for reliability can be satisfied by the ability to identify fault locations and isolate the faulted section while maintaining service to the remainder of the system. Where another feeder is nearby, service to de-energized, unfaulted sections of the feeder can be transferred to the second feeder. In these applications, switches include current monitoring that identifies fault current levels that are communicated to the station control. This identifies the fault location and isolates the fault by opening switches adjacent to it. These same switches can also function for routine load switching.

While such operating switches limit the number of customers that experience an extended outage, all customers on a feeder will experience a short-term outage while the substation device is operating to lockout, the switches are interrogated, and the appropriate switching functions are completed. This period of time is typically long enough to cause dropout of all digital timers on the affected part of the system, plus interruption of computer operations.

The number of short-term outages can be significantly reduced by an appropriate mix of reclosers and switches on the feeder (Fig 2). However, the increase in switches and reclosers increases maintenance significantly.

Cooper Power System, Milwaukee, Wis (USA) has developed a DA switch designed using modem technologies to provide a switching function. It uses solid polymer encapsulated vacuum interrupters which eliminates the need for gas or oil insulators. The switch consequently is described as maintenance-free. The vacuum interrupters are expected to last the life of the switch without repair or replacement.

After working with Cooper on the prototype of these new switches, Union Electric-Fenosa, the Spanish utility, is now installing 100 of the commercial switches in its distribution network to minimize customer outages. The switches will be manually controlled with information radioed back to a master controller.

ADVANCED AUTOMATION

In Finland and France, distribution networks are operated radially and their structure is partially meshed to allow backup routing. In France supply substations are equipped with main transformers of 63/20 kV, 90/20 kV, or 220/20 kV while in Finland they are typically 110/20 kV. All MV networks in both systems are three-phase and the 20-kV feeders are protected by a circuit breaker at the primary substation where protective relays are applied with autoreclosing and instantaneous tripping facilities for very high fault currents.

In Finland, over 60% of feeder faults are caused by weather conditions. This figure is related to the extensive use of overhead lines. In France, where underground networks predominate, faults are often caused by material damaged during civil-engineering work.

In both countries all utilities are equipped with Scada systems, customer information systems (CIS), and automated mapping/facilities mapping/geographic information systems (AM/FM/GIS). Integration of these databases has been realized in Finland. In France, customer and network data bases remain separate, but new MV network and geographical databases are currently being installed.

Two systems providing advanced functions for real-time management of these networks have been developed--Austral and Opera.

Opera. This system, developed by The Power Engineering Group of Tampere University of Technology, is an autonomous part of an integrated environment composed of Scada, an AM/FM/GIS, a customer database, and telephone answering machine. The system can be run anywhere on a local- or wide-area network (LAN or WAN). It includes many intelligent applications needed for network operation, including:

- Topology management.
- Load estimation and forecasting.

- Network calculations (load flow, fault currents, and outage costs).
- Detection of technical constraint violations and remedial control planning.
- Network optimization.
- Maintenance outage planning.
- Field crew management.
- Fault management.

Opera is currently in daily use by several utilities at over 10 control centers. For the pilot utility, Koilis-Saatakunnan Sahko Ltd, the annual mean outage time of a customer has been decreased by about 50% over the past few years using Opera in conjunction with other computer systems and DA devices.

Austral is currently being developed by Electricité de France (EdF), Paris. The first version is scheduled to operate this year in Nimes, Lyon, and Versailles. Goal is to provide a set of advanced functions ranging from incoming event analysis to power supply restoration. The main objective of Austral is to reduce overall outage time. This will be accomplished using two sets of functions--one to help the operator understand the workings of the networks, the other to propose actions for solving problems.

LIGHTNING STRIKES AGAIN

Today's electronic components have increasingly low insulation levels and are generally permanently energized. This equipment is therefore more sensitive to overvoltages from the network as it constitutes a dialectically weak point. Consequently, protection against overvoltages, especially from lightning, is getting increased attention.

Among the different causes of overvoltages on LV supply systems, lightning plays a prominent role when MV and LV lines are overhead. Overhead voltages from lightning result from various types of atmospheric conditions (Fig 3):

- Lightning strike on the MV line and transmission through the MV/LV transformer to the LV network.
- Direct strike on the LV line.
- Electromagnetic coupling between the line and a lightning strike to ground nearby.
- Direct lightning strike on the installation.

The characteristics of lightning over-voltages initiated on overhead distribution lines vary greatly depending on the strike characteristics, the generation of the overvoltage--direct or induced, and the orographic conditions (shielding effects from mountains) as well as line characteristics, including insulation level, presence of neutral conductors, etc.

Considerable attention had been given to direct-strike overvoltages because these cause the highest energy stresses on LV surge protective devices (SPD).

Because LV electrical equipment is more sensitive to overvoltage from lightning, it is helpful to assess the magnitude of these occurrences. A risk analysis can be conducted to decide whether installing a protective device is necessary. Methods of determining risk and defining tools to quantify the stresses is required. EdF and France Telecom, for example, have developed a program (called Anastasia) which calculates a statistical distribution of stresses and evaluates various protection strategies.

Lightning overvoltages on distribution lines has been the subject of numerous studies and research efforts. According to joint studies conducted by Cired and Cigre, optimized protection of equipment in MV distribution networks can only be achieved by means of surge arresters or spark gaps suitably dimensioned and positioned.

Arresters prevent lightning overvoltage, traveling along the line towards the substation, from damaging electrical insulation. The most important parameter for the selection of a metal oxide arrester is the highest power

DUTCH EXPERIENCE HIGHLIGHTS UNDERGROUND DISTRIBUTION

Unlike many other countries, the medium-voltage (MV) and low-voltage (LV) distribution net work in the Netherlands is almost completely underground. This represents about 200 000 km of underground cables and is said to account for the high reliability to Dutch electricity supply. The average outage time for a customer is less than 0.5 h/y.

Paper-insulated lead-covered (PILC) cable dominates the existing 12-kV MV infrastructure. In 80% of the country, 12 kV is the distribution medium. The PILC cable applied has a belt-type construction and is very suitable in a network without solid grounding. However, during the last few years, the number of failures in joints and terminations of PILC cables has increased.

Research over the past few years indicates that grease draining in the cable can cause problems. This especially true of the "light" PILC cable manufactured after 1980. The draining effect occurs with high and strongly changing loads which cause high over and underpressure in the cable. Under-pressure occurs when the cable is cooling and the resulting vacuum allows water inside the cable at leakage points. This mostly occurs near joints and terminations.

After 25 years, the polyester joints in the Dutch PILC-cable network are reaching the end of their useful lives. In heavily loaded connections, this is the source of first failures. Another problem is the forming of shrink hollows in mastic joints, also peculiar to PILC cable manufactured after 1980. This problem can be solved by filling the joint with mastic when mounting the joint and then waiting at least half a day before closing the joint.

In newly industrialized regions with higher growth rates, application of 20-kV line with single-core cross-linked polyethylene (XLPE) cable is quite common. In existing networks, however, many specialists prefer to continue with the application of PILC cable because they are concerned with possible transition problems. However, these transition problems are reportedly negligible, as the new 3-phase 12-kV XLPE cable fits smoothly in the existing 12-kV infrastructure. Because XLPE cable can handle much greater thermal load, it is preferred for cable circuits with strongly changing loads.

Dutch electricity suppliers first began using XLPE cable in the early 1970s. Many water-tree problems were encountered with this first generation of polymeric cable. This in turn has lead to several studies being conducted by utilities, including Iberdrola SA and Electricité de France, on the behavior of MV XLPE cable immersed in moist environments.

Performance of the XLPE cables made during the last 10 years, with raw, clean materials (super-clean materials for high-voltage cables) and special water blocking has significantly improved.

Now XLPE cable for the 12-kV level is also in demand. This type of cable is reliable, solid, and not too expensive. The XLPE cable must be compatible with the PILC cable, however. A copper ground-screen cross-sections of $70mm^2$ with standard core cross-section of solid 95-, 150-, and $240\text{-}mm^2$ aluminum (Al) for 3-phase cables is used. For the distribution cables, single-phase cables with a solid core of 400- or $630\text{-}mm^2$ Al with a ground-screen of 70 mm^2 copper is used. The cable is completely watertight in both directions. Longitudinal watertightness is achieved by using rubber and swelling tapes around each core as well as under the copper cable screen. The radial watertightness is achieved by using a relatively thick polyethylene outer sheath of about 3 mm.

The XLPE cable, like the PILC cable, is buried to a depth of 60 cm. Compared to the PILC cable, the XLPE cable is relatively difficult to bend. The XLPE cable is much lighter because of the absence of lead. Mountings and terminations are quite different. Attention must be paid to the interface between cable and premoulded accessories. If a problem does occur, chances are it is at this interface.

frequency voltage (Uc) which it can continuously withstand. In selecting the Uc of an arrester in a 3-phase network, the location of the arrester plays the deciding role: whether it is between phase and ground, between transformer neutral and ground, or between phases.

In 3-phase networks special attention must be paid to the expected temporary overvoltages generated by the system at the arrester terminal. The most severe temporary overvoltages normally occur in connection with ground faults.

The key parameters of spark gaps are the arching distance and the shape of the electrodes. The arching distance is chosen to obtain the required flashover voltage. The electrode is shaped to elongate and cool the arc, facilitating its extinction. A third electrode (at floating potential) is frequently put between the two main electrodes to avoid flashovers.

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* Courtesy: Electric Power International-USA.

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20 YEARS OF EXCELLENT SERVICES

NATIONAL DEVELOPMENT CONSULTANTS (NDC) REGD. LAHORE

PRINCIPAL FIELDS OF INTEREST

NDC undertakes Projects falling mainly in the realm of Civil Engineering and Allied Fields. The Principal fields of Interest are :

- **Irrigation and hydraulics**
- **Agriculture**
- **Drainage and groundwater resources development**
- **River training and flood protection works**
- **Surveys-topographic and socio economic**
- **Geo-technical investigations**
- **Physical modelling of hydraulic structures**
- **Dams and hydropower**
- **Forestry and rural sociology**
- **Project management and construction supervision**
- **Electrical and mechanical operations**
- **Roads and bridges**
- **Environmental engineering**
- **Tunnels**
- **Residential buildings and urban development**

SERVICES BEING PROVIDED

- **Investigation and Planning**
  - geological, geo-technical and soils surveys
  - topographic, hydrological and hydrographic surveys
- **Design**
  - computer aided designs
- **Tender Stage Assistance**
  - preparation of tender and contract documents
  - pre-qualification of bidders
  - bid evaluation and adjudication
- **Implementation**
  - construction supervision and contract administration
  - quality assurance and control
  - project management
  - support and strengthening of client's management teams
- **Operation and Maintenance**
  - preparation of operation manuals

OFFICES

55-M Gulberg-III, Lahore. Phone : (042) 5832064, 5837859.
62-M Gulberg-III, Lahore. Phones:(042) 5862033,5837824,852412,5860044,5860055,
FAX (042) 5862033.
26-K-II, Model Town, Lahore. Phones: (042) 5867773,5860870,5869287, FAX (042) 5869287

PROJECTS

NDC is substantially contributing individually and with Joint Ventures towards economic uplift of the Nation through the following major Projects :

-- Marala Ravi Link Canal System Restoration and Improvement Project, 82/2 Block-A Model Town, Lahore, Phones : (042) 5864554-55 , FAX (042) 5880289.
-- Chashma Right Bank Irrigation Project Stage-III, WAPDA Staff Colony D.I. Khan, Phones : (0529) 740402, 740248 , FAX (0529) 740401.
-- Swabi SCARP , WAPDA SCARP Colony, Charsadda Road, Mardan, Phones : (0531) 4973, 65827, 83089, FAX (0531) 65890.
-- Pehur High Level Canal Project , 2nd Floor Commercial Complex Block-II, Phase V , Hayatabad, Peshawar, Phones : (0521) 812049, FAX (0521) 812164.
-- Fordwah Eastern Sadiqia (South) Phase-I Irrigation and Drainage Project Drainage Component , 146-A-1 Township, Lahore, Phones : (042) 5112882, 5116634
FAX (042) 5116635
-- Post Flood Rehabilitation and Protection Project , House No.271, St. No.8 Cavalry Ground (Extension), Lahore Cantt. Phones : (042) 6667264, 6669012, FAX (042) 6669013.
-- Study for Development of Irrigation Uses in Punjab due to Water Accord, 147-M Gulberg-III, Lahore, Phones: (042) 856288, FAX (042) 5862033
-- Zaibi Dam Project, Mitha Khel, District Karak (NWFP), Phone: (05244) 210520 Ext.58.
-- Punjab Private Sector Groundwater Development Project, 89/A-1 Township.

CLIENTS

Some of the major Clients are listed below ;

-- Ministry of Water and Power , Government of Pakistan, Islamabad.
-- Ministry of Defence , Government of Pakistan, Islamabad.
-- Pakistan Water and Power Development Authority, Lahore.
-- Federal Flood Commission, Government of Pakistan, Islamabad.
-- Government of Punjab, Irrigation and Power Department, Lahore.
-- Government of NWFP, Irrigation Department, Peshawar.
-- Government of Balochistan , Irrigation and Power Department, Quetta.
-- Government of Sindh, Irrigation and Power Department, Karachi.