

**SUSTAINABLE TRANSFER OF COASTAL ENGINEERING KNOWLEDGE
AT POST GRADUATE LEVEL**

by

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ABSTRACT

Coastal engineering is a complex art. At this moment a limited number of phenomena can be understood with the help of the laws of physics and fluid mechanics. For the remainder, formulas have been developed with a limited accuracy. In addition, input data are limited availability and form another source of uncertainty. Consequently, a sound engineering approach is required, based on practical experience and supported by physical and numerical models, to increase the understanding of many phenomena and to come up with sustainable solutions. ‘Standard’ solutions do not exist in coastal engineering; solutions very much depend on the local circumstances as well as the social and political approach towards the coast.

Consequently, the transfer of coastal engineering (CE) knowledge is a complex art as well. The ‘standard’ classroom situation, where ‘standard’ textbooks are used to convey knowledge by a ‘standard’ lecturer can only cover the broad CE field to a very limited extend. Giving a CE training course at post-graduate level by one very experienced expert is not a solution either. Such course may lead to the situation that all aspects are treated at an introductory level only, or that just a very few aspects of the broad CE field are treated in sufficient depth but that their mutual relation remains unclear and that all other aspects are not covered.

Another complicating factor is that there is not just one type of coastal engineer. Actually, three kinds of coastal engineers can be distinguished (Verhagen, 1995, 1996):

- the *research engineers*, who are involved in expanding the understanding of the coastal processes by using advanced analysis of field data and sophisticated physical models;
- the *tool-makers*, who are involved in translating the newly gained knowledge into mathematical models and encapsulate this knowledge in various knowledge-based systems;
- the *design engineer (tool-users)*, who have their contributions in solving coastal problems in a multi-disciplinary team.

This paper mainly focuses on the third group: the design engineer. Sustainable transfer of coastal engineering technology at post-graduate level to design engineers should aim at increasing the capacities and skills of the engineers such that they are able to analyze a problem correctly, identify possible directions of solutions and know how to function in a multi-disciplinary team. Simply learning formulas and learning standard solutions for standard problems is not fruitful and even dangerous: such training

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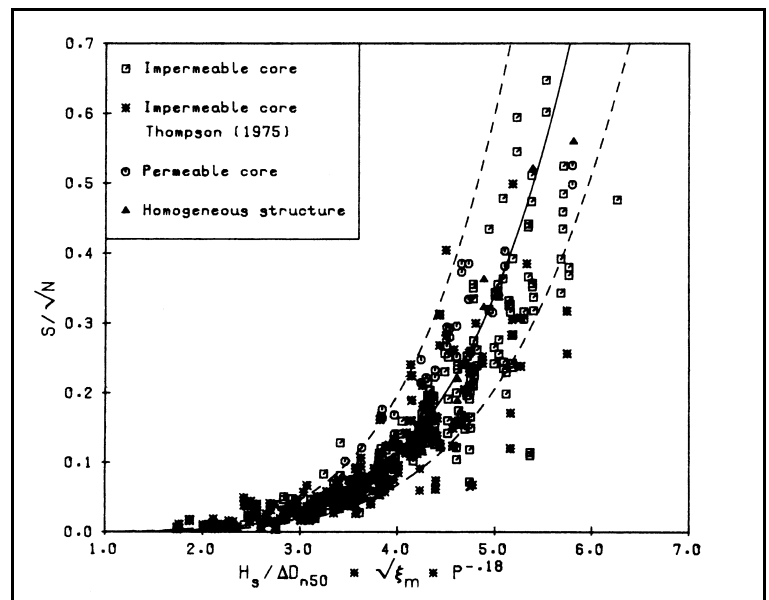
does not increase the engineer's understanding of the underlying processes and serious failures may be the result. Transfer of CE technology should therefore be problem oriented, practical in nature and geared towards the specific needs of the engineers following the training program.

The paper presents the complex field of coastal engineering and its consequences for the transfer of technology for engineers from developing countries. The experiences with the transfer of CE technology at IHE-Delft serves as illustration. In addition, related types of transfer of coastal engineering technology are described.

1 COASTAL ENGINEERING AS COMPLEX ART

1.1 Facing unreliability

Many processes in coastal engineering are only partly understood. Especially the interaction between waves and sediment or structures is still full of questions. Plots indicating the measured and computed sediment transport usually show clouds of data-points instead of points which are nicely located in one line. Often, the graphs are plotted on log-scale, which makes the cloud look thinner. However, detailed examination of the data shows that a 'prediction error' of a factor 10 is not unusual.



Another typical example is the stability of riprap. Also in this case, plotting the observed stable block-weight shows a thick cloud. And although research had decreased the thickness of this cloud considerably, the remaining thickness of the cloud still clearly indicates the significant level of uncertainty.

The conclusion from these two examples is that at present the predictive quality of many of the design formulas in coastal engineering is rather low.

In addition to the uncertainty in design formulas, we also face the uncertainty in input data. Very often, a one-in-several years condition is required. This figure can be determined by using statistics, provided that sufficient data are available. And usually this is not the case.

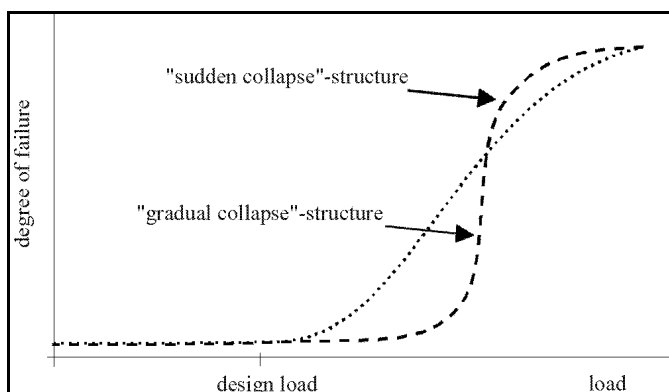
The consequence is that the reliability of CE designs is relatively low. This shows that sound coastal engineering can not be realized by simply filling in the parameters of the design formulas, resulting in clear answer. The results are more of an indicative character; they are values with high uncertainties.

1.2 Dealing with unreliability

The coastal engineer has to deal with many uncertainties. To make things even worse, coastal engineers in developing countries are often confronted with limited facilities (laboratories, computers, computer models), limited data (no historic data or no data for the site), limited engineering infrastructure, etc. Being placed in such an uncertain situation, a coastal engineer will look for successful concepts from elsewhere.

The current situation is that knowledge and expertise in coastal engineering is only available in a few, (mainly industrialized) countries. So successful CE concepts are based on the conditions in these countries too. To apply these concepts in his/her own situation, the coastal engineer can follow two approaches:

- *Copying concepts from industrialized countries.* In engineering, it is very tempting to copy concepts without further analyzing the conditions for which these concepts were developed. It is a very dangerous approach. This is especially valid for copying concepts from industrialized countries for application in developing countries. This danger is caused by the essential differences between the available resources in the developing and those in the industrialized countries. In the industrialized countries, there is a strong economic need to come up with designs that solve problems with minimal labor input. Simply because labor is very expensive. Thus, a capital-intensive solution is searched for. When such approach is simply copied by coastal engineers from a developing country, then they consequently come up with designs that are capital intensive, need equipment for installation that might not be available, etc. Such approach results in designs that are too costly for developing countries;
- *Utilizing available resources.* Financial resources are a constraint for developing countries. However, developing countries have abundant labor available. It is economically much more attractive to search for solutions which require hardly any capital investments, but are labor-intensive. It should be realized that these solutions often require more maintenance. However, increased maintenance costs may even be preferred, provided that the initial investment is very low. The total cost of the solution (investment plus maintenance) can be spread over a longer period without financial indebtedness.



As already indicated, the quality of the boundary conditions in coastal engineering is rather poor, especially in developing countries. This implies that the risk of ‘overloading’ is quite high. The design engineer has to be aware of that risk. He/she should design a structure in such a way that an ‘overload’

does not immediately result in a disaster (full failure; see Figure 2). Instead, overloading should preferably result in inconvenience and repairable damage. Structures which do not really collapse but gradually fail are therefore to be preferred. In addition, start of damage should preferably be visible. A comparison of the failure behavior of a riprap breakwater with a vertical wall breakwater shows this difference clearly. When a vertical wall is overloaded, the whole structure collapses and has to be rebuilt. In case of a riprap breakwater, the damage can be repaired easily, whereas the structure may still perform under normal conditions. In fact the structure ‘warns’ you that failure is eminent.

1.3 Examples of differences in design approaches

Example 1: Revetment

A revetment is needed for a structure that is located in a developing country. The design wave height is in the order of 1.5 m, because the water depth in front of this structure is not more than approximately 3.0 m. No foreign currency can be allotted for both the construction and maintenance of this structure. Further, the site is not easy to reach with equipment, whereas maintenance has to be carried out by local authorities (which will use local labor). We also assume that rock is available in this country, and that larger rock is more expensive than small rock.

The ‘standard’ design procedure is to apply the Van der Meer formula and fill in the given values ($H_s = 1.5$ m, $T = 4$ s, $\alpha = 1:3$, $S = 2$) which results in $W_{50} = 140$ kg. However, if a wave with $H_s > 1.5$ m or $T > 4$ s occurs, there will be damage. Repair of this damage is difficult, as not only rock needs to be supplied, but also a heavy crane will be needed to (re-)place these rocks.

So it might be useful to start the design differently. What is also given is that maintenance (and preferably also construction) will be carried out by local labor. The availability of equipment is a problem, so preferably rock-handling should be manually possible. This means that the rocks should have a $W_{50} \approx 50$ kg. If a slope $\alpha = 1:5$ is applied, and by using $H_s = 0.75$ m, then the Van der Meer formula results in $S = 3$. This means that damage may occur, but not that frequent. When an armour layer is made with a thickness of 4 to 5 rocks ($W_{50} = 50$ kg gives $D_N = 0.3$ m, which means that a layer thickness of 5 rocks is 1.3 m), then damage will not lead to collapse and the damage can be repaired manually. When a storm occurs with $H_s = 2.0$ m (higher than the design wave height), then damage will occur, but the repair works are still manageable. In this case, $S = 5$, which means only somewhat higher than initial damage.

Example 2: Groyne

As an example in a cost comparison for a design of a groyne is presented (Verhagen and Yap, 1992). It concerns a groyne with relatively low wave-attack, but it is located in an area with a strong tidal current (typical for an estuarine environment). To reduce tidal currents, wooden piles are placed on top of the groynes. A bed protection with boulders around the groyne is required to prevent scouring.

Such a groyne (which was recently built in the Netherlands) requires an investment of 725,000 MU (= Monetary Units, which can be any currency; its absolute value is not relevant). The yearly maintenance costs of the structure amount 3,600 MU. The economic lifetime of a good-quality groyne is approximately 30 years, after which the residual value is assumed at zero. Applying an interest rate of 4%, the total maintenance costs during the 30 years are capitalized to the present value, which is 17.3 times the required yearly maintenance cost, arriving at 62,000 MU. This is only 8.5 % of the total cost. Table 1 presents the details.

Table 1. Construction and maintenance costs of a groyne (high investment design)

Construction			<i>Industrialized country</i>		<i>Developing country</i>	
	<i>No.</i>	<i>Unit</i>	<i>Unit cost</i>	<i>Total cost</i>	<i>Unit cost</i>	<i>Total cost</i>
Wooden piles 3.5 m	193	pc.	40	7720	20	3860
Wooden piles 5 m	252	pc.	70	17640	35	8820
Wooden piles 6 m	12	pc.	85	1020	42	504
Wooden piles 7 m	24	pc.	100	2400	50	1200
Wooden piles 8 m	4	pc.	120	480	60	240
Wooden sheetpiles 2.5 m	608	m	170	103360	85	51680
Wooden sheetpiles 3 m	206	m	200	41200	100	20600
Geotextile	6390	m2	2	12780	10	63900
Placing geotextile	500	hr	40	20000	4	2000
Concrete blocks	3483	m2	40	139320	30	104490
Placing concrete blocks	2200	hr	40	88000	4	8800
Hydraulic asphalt	194	t	190	36860	150	29100
Stones 25/80	820	t	60	49200	40	32800
Stones 80/200	930	t	55	51150	55	51150
Phosphorous slag 40/250	310	t	35	10850	60	18600
Bituminous grouting morting	460	t	250	115000	250	115000
Extra labor	50	hr	40	2000	4	200
Use of shovel	25	hr	60	1500	10	250
Use of vibration crane	20	hr	70	1400	12	240
Contingencies				5000		5000
Subtotal				706880		518434
Unforeseen, risk	2.25	%		17672		12961
<i>Total construction</i>				724552		531395
Maintenance (per year)						
Labor	50	hr	40	2000	4	200
Use of shovel	10	hr	60	600	10	100
Stones, geotextile				1000		1000
Total maintenance				3600		1300
Interest rate 4%, 30 years, multiplier				17.29		
<i>Capitalized maintenance cost</i>				62244		22477
Total project costs				786796		553872

In a developing country, a laborer costs much less: it is taken at 10 % of that in an industrialized country. However, geotextile is much more expensive. Making the same calculation with unit costs from a developing country gives quite a different result.

An alternative design has been made (see Table 2). Geotextile has been replaced by jute, the concrete blocks by pitched stone, etc. Phosphorus slag is easily available in the Netherlands, because it is a rest-product of nearby industries. It has been replaced by quarry stone. The stone-weight of the various stones is somewhat lower. Also less asphalt and bituminous grout is used. The consequence of this alternative is more damage to the groyne during storms, and thus significant higher maintenance costs.

Of course this is a very rough comparison. For instance, differences in productivity of a laborer are not accounted for, the price of the boulders should depend on the available quarry in the vicinity, etc. But the comparison clearly illustrates that the low investment design is certainly not attractive for an industrialized country. In addition to the higher initial costs (920,000 MU vs. 725,000 MU), the

maintenance costs are a real problem (284,000 MU vs. 62,000 MU). For an developing country, however, the situation is completely opposite. There, the alternative is on the long run 18 % cheaper (450,000 MU vs. 554,000 MU). Very important and attractive is the 35 % lower initial investment (345,000 MU vs. 531,000 MU).

Table 2. Construction and maintenance costs of a groyne (low investment solution)

Construction			<i>Industrialized country</i>		<i>Developing country</i>	
<i>Item</i>	<i>No.</i>	<i>Unit</i>	<i>Unit cost</i>	<i>Total cost</i>	<i>Unit cost</i>	<i>Total cost</i>
Wooden piles 3.5 m	193	pc.	40	7720	20	3860
Wooden piles 5 m	292	pc.	70	20440	35	10220
Wooden sheetpiles 2.5 m	608	m	170	103360	85	51680
Wooden sheetpiles 3 m	206	m	200	41200	100	20600
Jute filter cloth	6390	m ²	3	19170	1	6390
Placing jute filter cloth	500	hr	40	20000	4	2000
Pitched stones	3483	m ²	60	208980	25	87075
Placing pitched stones	5000	hr	55	275000	6	30000
Low graded asphalt	250	t	150	37500	75	18750
Stones 25/80	2500	t	60	150000	40	100000
Extra labor	200	hr	40	8000	4	800
Use of shovel	25	hr	60	1500	10	250
Contingencies				5000		5000
Subtotal				897870		336625
Unforeseen, risk	2.25	%		22447		8416
<i>Total construction</i>				<i>920317</i>		<i>345041</i>
Maintenance (per year)						
Labor	200	hr	40	8000	4	800
Use of shovel	20	hr	60	1200	10	200
Stones, jute				3000		3000
Replacement of piles	50	pc.	85	4250	42	2100
Total maintenance				16450		6100
Interest rate 4%, 30 years, multiplier				17.29		
<i>Capitalized maintenance cost</i>				<i>284420</i>		<i>105469</i>
Total project costs				1204737		450510

1.4 Low-investment solutions

From the foregoing examples, two conclusions can be made:

- understanding of processes, insight in reliability and appropriate use of formulas may lead to sound engineering solutions in developing countries, despite the CE scarcity (of data, means etc. (Example 1));
- sustainable solutions can be obtained, on the condition that these are based on the low-investment approach (Example 2).

The term low-cost approach is sometimes misleading. The argument to use such an approach is that developing countries can not afford high-cost solutions. However, this reasoning is not correct! Industrialized countries are, of course, very much interested in cheap solutions as well. Why choose a more expensive solution if it can be done cheaper?

For a good interpretation of the term low-cost, it should be realized that the involved costs are not really low. The total costs for every structure comprises of the initial investment and the maintenance costs. Comparison of the totals of 'high-cost' and 'low-cost' solutions shows that both are in the same order of magnitude (see Tables 1 and 2). Their essential difference concerns the distribution of the costs. It can even occur that on the long run the 'low-cost solution' (in industrial countries) would be more expensive than the 'high-cost solution'. So the term 'low-cost' is misleading; it is better to speak about low-investment solutions. When availability of money is no restriction, the cheapest solution on the long run should be selected. In the industrialized world that is generally the high investment solution, in the developing world generally this is the low-investment solution.

Characteristic for low-investment solutions is that they generally require more maintenance than capital intensive solutions. Therefore, the structure has to be designed in such a way that maintenance can be conducted easily with local means, i.e. local material, local laborers and local equipment. These requirements are not new, and obviously not very special, and they can be met relatively easily. The trick is that the coastal engineer should be aware of these requirements during the design phase.

To illustrate this, we take a rubble shoreline protection as example. Having the maintenance requirements in mind, such a protection should be designed in such a way that repair works can be done directly from the shoreline. To facilitate this, a maintenance road has to be available. The boulders should be such that they can be placed with local cranes, generally with a short boom. In addition, the individual boulders should not be too heavy. In addition, these boulders should be available from local quarries. When the construction is designed with concrete elements, these elements should be simple to manufacture and handle. Concrete cubes are preferable above fancy elements, like dolosses, akmons and tetrapods.

2. TRANSFER OF COASTAL ENGINEERING TECHNOLOGY

2.1 Boundary conditions for training

One could formulate the task of a coastal engineer as:

to make a reliable and economic design, based on rather unreliable input, computational results and taking into account the available resources.

Post-graduate training should realize an upgrading of participants such that they can fulfill the above defined task.

In addition to the difference in the technical aspects of coastal engineering between the traditional CE countries and most of the developing countries (Chapter 1), other differences play an important role:

- *career development.* In countries with a CE-tradition, the young engineer gets a good basic education at university, where he learns all the fundamentals of coastal behavior. In his first job, a young engineer learns how to apply this fundamental knowledge. As starting engineer, he will first be involved in projects guided by more senior coastal engineers, so that he can build up experience and get a feeling for the relativity of the computations. In other words, the young engineer can build up experience in a rather protected environment. Therefore, the education in industrialised countries should mainly focus on the basics of coastal engineering and on understanding of processes.

For engineers from developing countries this focus is not enough. In most cases, young engineers do not have the luxury of obtaining experience like indicated for those in countries with a CE tradition. After graduation, they almost immediately are put in a position as 'expert'. In addition, when they are guided by a more senior engineer, than often this senior engineer is not an experienced coastal engineer (Verhagen, 1995);

- *engineering network*. Keeping in touch with the profession is very essential, which requires an engineering network. In the ‘non-traditional CE countries’, however, a network of experienced coastal engineers is often absent. So, our young expert can not go to his former study-mates or to a specialised library for consultation. Fortunately, electronic data communication eases the life of the remote engineer nowadays. He can have access to computer libraries and make contact with colleagues on the other side of the globe;
- *engineering facilities*. Availability of well equipped laboratories, computer models, computers, measuring equipment, vessels, etc. is a pre-requisite for successful coastal engineering. However, developing countries often lack these facilities or face problem in obtaining finances for operation and maintenance of these facilities.

An additional factor is that CE knowledge and expertise at post-graduate level is only available in a few countries (to illustrate this: at the ICCE’98 there were only 9 countries with more than 10 participants present). The need for CE technology, however, is high in many countries all over the world, especially in developing countries. Here, problems are increasing, both in complexity, number and magnitude, whereas the resources are very limited available.

2.2 Consequences for a training program

Transfer of CE technology at post-graduate level for developing countries should aim at increasing the capabilities and skills of the design engineers such that they can analyze CE problems and identify possible directions of solutions themselves. A sustainable transfer of technology implies a decrease dependency on foreign expertise.

Essential elements in such transfer are:

- bringing engineers and experts together, so that they can exchange knowledge, views and experiences;
- introduce engineers to practical tools (such as software) and learn them when to use them and how to interpret results;
- expose the engineers through exercises, case studies and field visits to CE practice with the emphasis on the underling philosophies that have lead to certain solutions.

Availability of experts

Direct personal communication with a relatively high number of experts and exposures to CE examples in the field are essential elements of realizing sustainable transfer of CE technology.

Bringing engineers and experts together is a main problem: experts are mainly located in a few countries with a CE tradition, whereas the need for training is worldwide. Further, the experts are very limited available. So the engineer has to come to the experts. There are three possible solutions:

- A. the engineer attends a *post-graduate coastal engineering course* at a university in a country with a CE-tradition. However, major difficulties of this option are:
 1. the number of post-gradual training courses is very limited and only given in traditional CE countries;
 2. post-graduate training programs are often PhD programs, which mainly focus on research. And this is not what our design engineer is looking for;
 3. the engineer has a completely different background and reference level compared with that of the fellow students and the lecturers;
 4. the course may be geared to the specific needs and circumstances of the country where the course is given;

Consequently, the engineer runs the risk that he/she ends up with a course, that is just partly relevant for the specific needs of his/her own situation;

- B. the engineer attends a *regular masters course*. Characteristics of this option are:
1. the number of masters courses is limited and the majority is located in countries with a CE-tradition.
 2. in addition to the sketched difficulties A1 and A2, the fellow students come directly from the under-graduate program and consequently lack practical CE experience;
- A complicating factor of options A and B might be the language. The majority of these courses is given in the native language, which should be mastered by all students. When this is not the English language, our engineer first has to spend a lot of time (several months up to one year) and effort to learn this language before he can actually start the course.;
- C. engineers from all over the world come together at a location close to the experts and attend a training course that is geared to their specific needs and backgrounds, and where they can share their experiences with colleague engineers. At IHE-Delft we have experienced that this option can only be effective when participants have attended a qualitative good preparatory CE-course at university-level in their home country (which should meet internationally accepted standards) and have relevant experience in practical coastal engineering. To keep the course practical oriented and to include the latest CE developments, we have included over 50 so-called guest lecturers in our faculty: experts with abundant international experience, who work for mainly consultants, universities and government institutes and lecture to our participants.

Orientation of training

The examples of Chapter 1 indicate that the training should be geared at understanding the underlying CE processes (copying solutions from the industrial countries usually do not lead to the most optimal/economic solution for their own problems), and the development of conceptual thinking (as to decrease dependency of foreign CE expertise). Background for such approach is:

- *ongoing developments in the CE field*. Training students in the use of formula only is not that relevant, because the current formulas will be replaced by newer and better ones. For example, nowadays one can better use the Queens formula instead of the CERC formula, or the Van der Meer formula instead of the Hudson formula. In other words, because of the ongoing research in our profession, formulas are continuously replaced by others. Therefore, after training our engineer should be able to:
 - know about these new developments;
 - judge the quality of these new formulas (are they better, for which conditions are these formulas developed, what are the limitations in use);
 - learn himself how to use a new formula;
- *latest techniques*. For the complex CE problems and the limited data available, the coastal engineer from a developing country has to have access to the latest knowledge and techniques. The training should be geared such that the student is able to use newly developed models;
- *capacity for interpretation of engineering results*. This refers to training students in the interpretation of results of a given a computational method. For example, if the outcome of the Van der Meer formula is rocks with a weight of 523 kg, than how should this outcome be interpreted? Should only rocks be applied that exactly weigh 523 kg? Should the rocks have a minimum weight of 523 kg? Should the average rock weight be 523 kg, and if so, what should be the range (standard deviation) of the rocks.

2.3 The role of a coastal engineer in a multi-disciplinary team

Coastal engineering problems are often part of problems in coastal zone management. In addition to safety and protection, more functions of the coastal zone have to be taken into account. This implies that more disciplines are involved, like marine biology, water quality, landscape, demography, socio-economy. When planning works in the coastal zone it is therefore essential to have a thorough knowledge of the interaction between all the various functions intervening in the coastal zenith coastal

zone is not only the coastal strip, it also includes estuaries, tidal rivers and adjacent settlements, agricultural and aquacultural farmyards, as well as towns and coast related industrial complexes. Development plans, which affect the rivers and estuaries, also influence the coastal zone.

Post-graduate training of design engineers should also address these issues. A coastal engineer should understand the complexity of coastal zones and the role of coastal engineering in this field. In addition to understanding physical processes and mastering CE tools and formulas, our coastal engineer should also be capable to function in a multi-disciplinary team.

Including these requirements in an engineering course is far from easy. It is rather time consuming (thus in competition with the engineering part of the curriculum) and engineers are often not primarily interested in these 'soft' subjects. Our experience at IHE-Delft shows that:

- in-depth treatment of *non-engineering subjects* should preferably be done by coastal engineers with sufficient (theoretical and practical) background of these subjects, as specialists in areas like biology, economy, physical planning speak their 'own, non-engineering (soft) language';
- transfer of *transferable skills* (like project management, report writing, presentation techniques, team role management, policy analysis, etc.) should receive ample attention in the curriculum;
- design engineers should be exposed to a multi-disciplinary environment through workshops, where they:
 - experience the importance of non-engineering aspects of a coastal zone;
 - learn to communicate with representatives of non-engineering fields;
 - formulate alternatives for complex problems including non-engineering aspects;
 - experience the 'ins and outs' of the decision-making process.

Our yearly workshop on Integrated Coastal Zone Management may serve as example. This workshop is part of the CE curriculum of IHE and is attended by both Dutch students (studying at Dutch universities) and IHE participants (who follow the post-graduate CE course: they have after their university studies in their own countries obtained at least three years of practical experience). In this course, participants experience that making an Integrated Coastal Zone Management plan is one thing, but that implementation is of complete different order. For the Dutch students, it is revealing that the problems of their colleagues from developing countries are so different (difference in the decision making, degree of civil organization, effect of rules and regulations), and that IHE participants have a rather modest contribution to discussions. For the IHE participants it is revealing that the Dutch students have so little practical experience and are so dominantly present in a team and in the discussions.

2.4 Institution development

Transfer of CE technology also includes in increasing the number of locations where CE education is provided. This requires that in addition to training CE engineers, universities and institutes should be provided with sufficient staff and means to facilitate transfer of CE technology locally, for which a number of actions are required:

- training of trainers programs;
- upgrading curricula at universities to a masters level;
- upgrading university staff to PhD level.

2.5 Future developments

Future developments in training will be directed to the development of *distant learning* techniques. Background for this is that the current method of training requires the physical presence of the design engineer. At IHE-Delft it means that the design engineer is absent from his job for 12 of 18 months (Master of Engineering resp. Master of Science course). Employers are very much interested in reducing such durations. Developments in distant learning are rather promising, but it can never be expected that these techniques will replace courses entirely. To our opinion, a person-to-person contact with both the experts and colleagues is needed for a complete transfer of technology at post-graduate level.

3. CONCLUSIONS AND RECOMMENDATIONS

Transfer of CE technology at post-graduate level should aim at:

- development and improvement of conceptual thinking;
- increase the understanding of physical processes;
- increase the managerial capabilities of the course participants;
- understand the role and importance of coastal engineering within coastal zone management.

A sustainable transfer of CE technology at post-graduate level to engineers should comprise:

- personal contact with a relatively high number of experts;
- practical oriented curriculum, covering the many components of coastal engineering(which is more than only factual knowledge);
- exposure to different cases in different situations (physical as well as social/cultural);
- integration of all CE components.

The curriculum for the training of CE students from developing countries can not be identical to a curriculum for the training of students from countries with a strong CE tradition. Over the last 40 years IHE-Delft has build up a considerable experience in teaching students from abroad, which has resulted in a training with is on a comparable level of the CE-training at Delft University, but certainly not identical. Especially more attention has to be paid to a clear definition of the attainment targets (Verhagen, 1996).

Realizing a successful transfer of technology implies an intensive guidance of both the engineers attending such training as well as their trainers.

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