*Ir. J. agric. Res.* **15**: 207-221, 1976

# PHYSICAL PROPERTIES OF IRISH PEATS

L. F. Galvin

*An Foras Talúntais, Kinsealy Research Centre, Malahide Road, Dublin 5*

## ABSTRACT

In Ireland, peatlands can be divided into two major categories: blanket bogs which occur along the western seaboard and on high ground elsewhere; and raised-bogs which occur in the central plain of the country. The raised-bogs usually consist of layers of reed-fen or woody-fen peat underlying older and younger sphagnum peat, depending on location and conditions pertaining at the time of formation.

In this study typical blanket peat and five types of raised-bog peat were subjected to a comprehensive physical analysis. The results are reported and discussed under the headings: degree of humification; pH; ash content; specific gravity; porosity and void ratio; bulk density; hydraulic conductivity; infiltration capacity; water retention; shear strength and consolidation characteristics. A straight line semi-log equation (correlation coefficient = 0.970) was derived to describe the relationship between the saturated hydraulic conductivity and drainable porosity of homogeneous peats. The results quantify the physical parameters of the major peat types in Ireland and thus provide a basis for the design of effective and economic reclamation and water management schemes.

## INTRODUCTION

In Ireland, peatlands are divided into two major categories, namely, blanket bogs and raised bogs (1). The blanket bogs cover extensive areas along the western seaboard, where the annual rainfall averages about 1400 mm, and also extend over high ground elsewhere, e.g., on the Wicklow mountains near the east coast. The total area of blanket bog has been estimated (2) at 870,000 hectares, of which about 8,000 hectares are being developed for fuel production by Bord na Mona. Blanket bog peat has an average depth of around 2.5 m and is relatively uniform in composition throughout the profile. The raised bogs are largely confined to basin-type situations in the centre of the country where the annual rainfall is around 850 mm. Such deposits occupy an area of approximately 500,000 hectares (2) of which Bord na Mona own around 60,000 hectares, the remainder being in private hands. It is estimated that some 100,000 hectares of raised bog have already been cut-over for fuel production. In contrast to blanket bogs, raised bogs frequently exhibit in section a distinct sequence of peat types that reflects the changing environmental conditions from a low-moor stage, represented by reed-fen or woody-fen peat, to raised bog which develops above the influence of ground-water and is characterised by the presence of peat derived from sphagnum, cotton-grass and related species (3).

After the fuel harvesting process, different peat types are left exposed. As the cut-over bogs are now being developed for agricultural and other purposes, accurate information on the physical properties of the different peat types is required if effective and economic water management schemes and utilisation methods are to be designed. In the work described, some important physical characteristics of the more commonly occurring peat types are presented and discussed.

## EXPERIMENTAL AND RESULTS

*Peat types*

The following peat types were examined: (a) Blanket Peat, (b) Younger Sphagnum, (c) Older Sphagnum, (d) Woody-Fen (Type B), (e) Reed-Fen (Type C) and (f) Woody-Fen Phragmites (Type B/C). These peat types have been described in some detail elsewhere (3).

Samples of Blanket Peat and Younger Sphagnum peat were taken from the upper layers of bogs: samples of all the other types were taken from cut-over bogs, where different horizons had been exposed by the removal of milled peat for fuel.

*Physical analyses*

*Degree of humification:* The degree of humification was determined using the method devised by von Post (4). Strictly speaking this method is only applicable to samples of raw peat, particularly sphagnum peat, taken from undrained bogs. Evaluation of the other peat types was achieved by combining a squeezing test of water-saturated peat with a visual inspection of the organic residues. The results are given in Table 1.

*pH value:* For each type of peat a mixture containing 20 ml of distilled water and 10 ml of air-dried peat was prepared and a pH meter incorporating a glass electrode was used to give the required results (see Table 1).

*Ash content:* An oven-dry sample of peat was ignited in a furnace at 500°C for 4 hours. The ash content was calculated by dividing the weight of ash by the dry weight of peat. The results are set out in Table 1.

*Specific gravity:* The specific gravity was measured on a number of samples of each peat type. A range of laboratory techniques was tested and a variation of the method described by Akroyd (5) adopted. This method gave very satisfactory results when the

TABLE 1: Physical properties of various peats

| | Type of peat[a] | | | | | |
|---|---|---|---|---|---|---|
| | | | | | *Woody-fen* | |
| | Blanket | Y.S. | O.S. | Reed-fen | B | B/C |
| Natural moisture content (% dry weight) | 1,057 | 1,607 | 995 | 894 | 821 | 929 |
| Natural moisture content (% by volume) | 88.9 | 91.3 | 88.9 | 85.7 | 90.9 | 91.0 |
| Degree of humification | H8 | H2 | H8 | H8 | H6 | H7 |
| pH | 4.1 | 4.2 | 4.7 | 6.0 | 5.4 | 4.5 |
| Ash content (%) | 1.5 | 1.6 | 1.0 | 7.3 | 7.8 | 7.4 |
| Specific gravity | 1.31 | 1.36 | 1.36 | 1.38 | 1.38 | 1.36 |
| Void ratio | 17.8 | 23.0 | 15.0 | 14.5 | 12.7 | 14.8 |
| Porosity (%) | 94.7 | 95.8 | 93.7 | 93.5 | 92.7 | 93.7 |
| Unit weight at saturation (kg/m$^3$) | | | | | | |
| Natural | 1,021 | 1,006 | 1,023 | 1,027 | 1,030 | 1,023 |
| Dry | 70 | 56 | 85 | 89 | 101 | 86 |
| Hydraulic conductivity (mm/day) | | | | | | |
| Laboratory | 13 | 208 | 5 | 49 | 8–183 | 6 |
| Field | 6 | 209 | 28 | 126 | 564 | 648 |
| Infiltration (mm/day) | 4 | 61 | 3 | 13 | 29 | 2 |
| Moisture content at pF 2 (% by volume) | 78.6 | 57.6 | 76.5 | 79.8 | 84.5 | 83.1 |
| Drainable porosity (ml/ml) | 0.16 | 0.38 | 0.17 | 0.14 | 0.08 | 0.11 |

[a] Y.S. = Younger Sphagnum; O.S. = Older Sphagnum

tests were carried out in a constant-temperature room. The peat was dried at 85°C, pulverised, weighed and placed in a fixed-volume flask. Petroleum spirit was measured into the flask from a burette. The flask was then placed under vacuum until all the air was exhausted after which the flask was filled to the graduated mark from the burette. The volume of spirit displaced was thus found and the specific gravity of the peat calculated by dividing the dry weight by the volume of liquid displaced (equal to the volume of peat). The results are set out in Table 1.

*Void ratio:* The void ratio ($e$) is defined as the ratio of volume of voids to volume of solids. It was determined by completely saturating a sample of peat and measuring its moisture content at saturation. Since the volume of voids is equal to the volume of water at saturation, which in turn equals the weight of water at saturation, the void ratio can be calculated by multiplying the moisture content at saturation (% dry weight) by the specific gravity of the peat. The results are given in Table 1.

*Porosity:* Porosity ($n$) is defined as the ratio of volume of voids to total volume (solids+voids) and is therefore equal to $e/(1+e)$. The calculated void ratio for each peat type was used to derive the corresponding porosity. Results expressed in percentage form are given in Table 1.

*Unit weight (natural):* The unit weight (natural) of each peat type was determined at saturation in the following manner. Undisturbed core samples were taken in thin-wall, fixed-volume tubes (58.3 mm diam. × 25.4 mm high). The samples were roughly

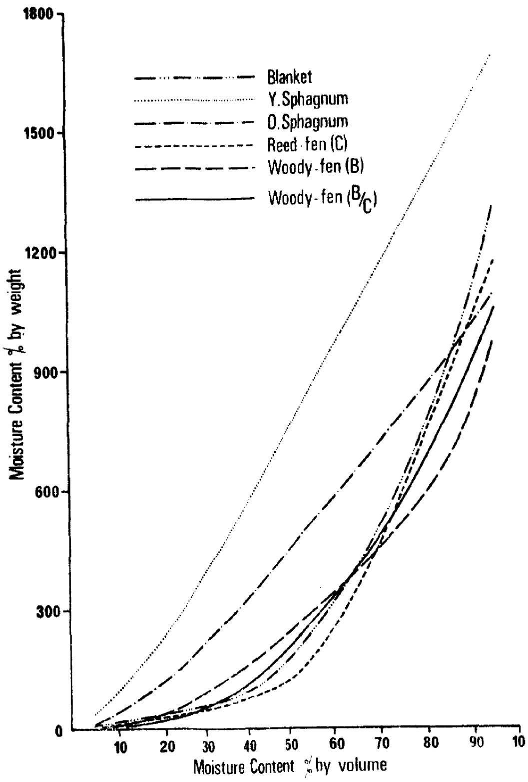


*Fig. 1: Relationship of moisture content (% by weight) to moisture content (% by volume) for Irish peats*

trimmed to size and saturated by placing in water under vacuum for 24 to 48 hours. Each sample was then trimmed accurately to size, weighed and the unit weight (natural) at saturation calculated. The saturated moisture contents were also determined to ensure that all the samples had been fully saturated.

*Unit weight (dry):* The dry unit weight (bulk density) of each peat type was measured over a range of moisture contents. The system adopted was to take a large number of undisturbed core samples (60 to 70) in the thin-wall, standard volume tubes already described. All samples were saturated by immersion in water under a small vacuum and then trimmed to size. On six of these samples the bulk density and moisture content at saturation were determined. The remaining samples were allowed to dry slowly on the laboratory bench, the bulk density and moisture content being determined at intervals to give a complete range of values from saturation to very low moisture contents that varied from 5 to 20% by volume, depending on peat type.

To measure the volume of air-dried samples, dry uniform sand (300 to 600 micron size) was poured into each container to fill the voids created by the shrinkage of the peat. The container was tapped gently, the surplus sand brushed away and the container plus peat plus sand re-weighed. From this, the weight of sand added was calculated and from the known bulk density of the sand, the volume of added sand was derived. By subtraction from the core volume, the volume of the peat sample was derived.

Samples of the peat were carefully removed from all cores, their moisture contents determined and the dry weights of peat calculated. The weight of dry matter per unit volume of sample (dry unit weight) was then determined for each sample and by using the relationship MCV = MCW × BD (moisture content on a volume basis = mois-

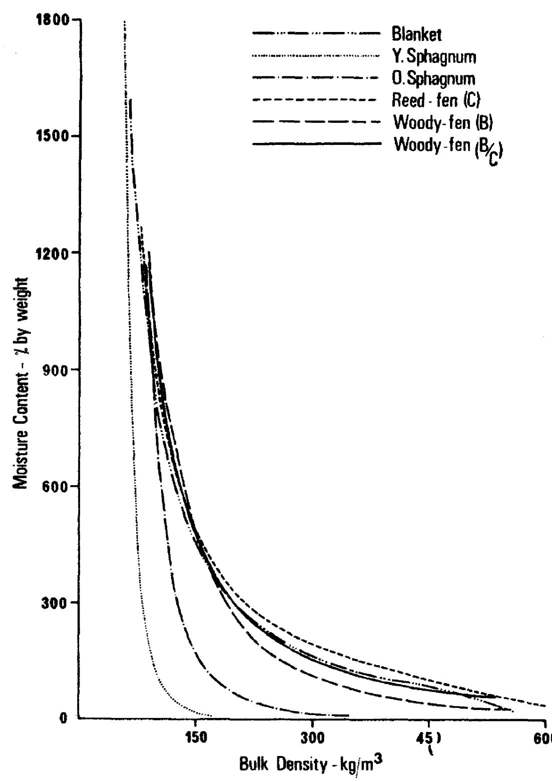


*Fig. 2: Relationship of moisture content (% by weight) to bulk density for Irish peats*

ture content on a dry weight basis × bulk density) the corresponding volumetric moisture contents were calculated.

Linear, quadratic, cubic, semi-log and log-log regression equations were derived for MCW on MCV, BD on MCW and BD on MCV for each peat type. The resulting curves (for each peat type) and the corresponding experimental data were then plotted and the curve of best fit determined. With the exception of Reed-fen (Type C), the log-log curves fitted the plotted points best. In the case of Reed-fen the log-log curve (corr. coeff = 0.962) also fitted well but the cubic equation (corr. coeff = 0.972) gave a closer approximation to the plotted points and was used. High correlation coefficients were achieved (ranging from 0.993 to 0.947) and the selected equations were used to produce the curves (Figs 1 and 2) which show the relationship between MCV, MCW and BD for each peat type. Values of unit weight (natural and dry) for the various peat types at saturation are set out in Table 1.

Boelter and Blake (6) and others have pointed out the importance of expressing the moisture contents of organic soils on a volumetric rather than on a gravimetric basis. Very misleading impressions can be obtained by comparing the gravimetric moisture contents of materials having different bulk densities. In such cases a true reflection of the relative moisture-holding capacities can be derived only by using volumetric moisture content. Many results pertaining to moisture content in this study have therefore been converted from gravimetric to volumetric figures by referring to Fig. 1, and volumetric moisture contents (MCV) are generally quoted in the remainder of the paper.

*Hydraulic conductivity (laboratory tests):* The hydraulic conductivity of the peats was determined in a simple constant-head type apparatus (Fig. 3). The peat samples (101 mm long × 73 mm diam.) were taken in stainless steel, thin-wall tubes. These samples were saturated, trimmed to size and mounted on the apparatus under a head of water of about 150 mm. The siphon arrangement was started and the rate of flow was measured by stop watch and graduated cylinder. The size and graduation of the collecting cylinder used were varied, depending on the rate of flow through a particular sample.

The results obtained (Table 1) were generally reproducible although, in an occasional sample, the water bypassed the peat mass along the cylinder wall. This occurred on some of the woody samples and on some Younger Sphagnum samples of low humification.

*Hydraulic conductivity (field tests:)* Field measurements on the raised-bog peats were carried out, using both auger hole and piezometer methods. The results, previously reported (7), have been abstracted and averaged for the present publication.

The field measurements on blanket peat were carried out using the auger hole and well-drawdown techniques. The results are given in Table 1.

*Infiltration measurements:* The infiltration capacities of the different peats were meas-

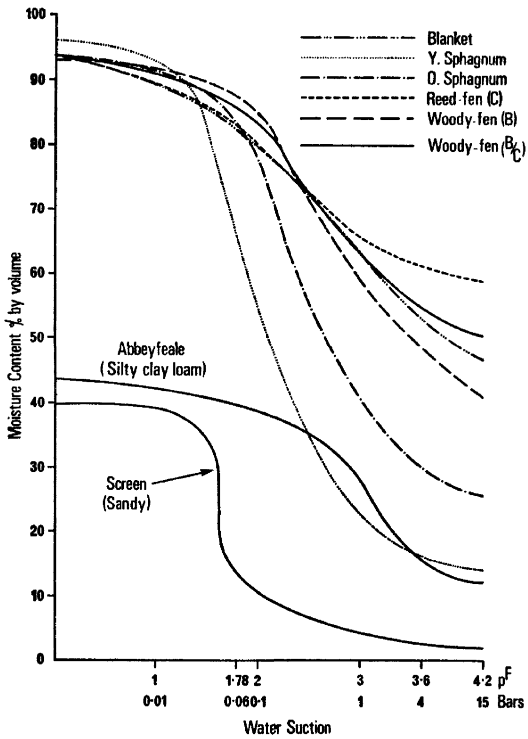


*Fig. 4: Relationship of moisture content (% by volume) to water suction—pF curves for six Irish peats and two mineral soils*

ured in the field using a double-ring infiltrometer. Problems arose in levelling off the surface prior to the installation of the infiltrometer. It was difficult to avoid smearing the saturated peat and this can lead to a reduction in the measured infiltration capacity. Steps were taken to reduce this to a minimum by roughening the surface after levelling, prior to the application of the water. The results are given in Table 1.

*Water retention:* The water retention was derived from the pF curves (Fig. 4). These were prepared for each type of peat from measurements of moisture content at tensions ranging from nil (saturation) to pF 4.2 (wilting point). Suctions of 100 mm (pF 1), 600 mm (pF 1.78) and 1,000 mm (pF 2) were applied to peat samples on sand tanks, and a pressure membrane apparatus (using compressed nitrogen) was used to determine the equilibrium moisture contents at the higher pF values: 3, 3.6 and 4.2.

Fig. 5 shows the drying curve and three re-wetting curves for Older Sphagnum peat. The re-wetting curves are typical of those obtained on re-wetting cycles for all the peats tested.

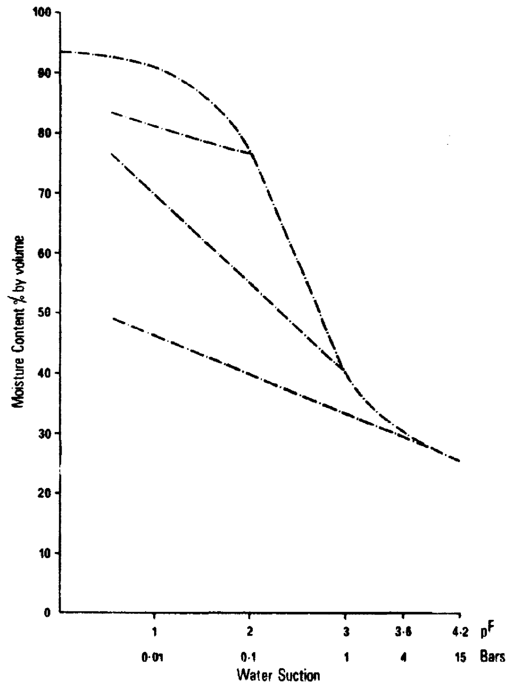


*Fig. 5: pF curves for Older Sphagnum showing drying and three re-wetting cycles*

*Strength:* The shear strength/moisture content relationship for the different peats was determined in the laboratory for undisturbed and remoulded samples using a four-bladed 12.7-mm square vane. The rotation of the vane was motorised to give a constant rate of feed of about 20° per minute. This type of vane had been used previously by Hanrahan (8) with very satisfactory results.

Undisturbed samples of each peat type were taken in thin-wall tubes (150 mm diameter × 150 mm long). These were carefully pushed into the peat and the surrounding peat mass was then excavated, and trimmed to core size. They were then carefully packed and transported to the laboratory where they were divided into two batches. All samples in one batch were extruded from the sample tubes, remoulded and replaced in the tubes. Some difficulties were encountered initially in repacking the remoulded peat at its original density but after a little experience with each peat type, the pressure, that needed to be applied to the individual layers, to achieve the correct density was determined. Both batches of samples (undisturbed and remoulded) were then ready for testing.

The following test procedure was adopted: The peat was allowed to dry out gradually from its field moisture content (samples were taken when the peats were near saturation) and the vane strengths and corresponding moisture contents were measured at intervals until the peat was so dry that the vane was unable to shear it. This could have been accomplished by allowing the samples to dry out gradually on the bench and checking the strength at intervals. However, the process was speeded up by partially drying some of the samples in a slow oven to different moisture contents. All the samples were then allowed to dry out slowly on the bench and the strengths measured over the whole range of moisture contents. In all tests, the vane strength was measured in the top 30-mm layer of peat in each sample tube. Ten separate vane measurements were made over the area of the tube with the vane about 10 mm under the surface. The results were averaged to give the vane strength and a sample of peat from the test-layer was taken for moisture content determination. The top 30-mm was then carefully scraped off and another layer exposed for further drying and subsequent testing at a lower moisture content.

When the full range of moisture contents had been covered for undisturbed and remoulded peat, the results (45 to 60 in each set) were analysed in a similar manner to that described for the bulk density measurements, and the most appropriate regression equation adopted. Correlation coefficients were high, ranging from 0.984 to 0.908 except in the case of Older Sphagnum (undisturbed), which had a value of 0.847. With the exception of Type B, the results of tests on the remoulded samples had higher correlation coefficients than those of the tests carried out on corresponding samples of undisturbed peat.

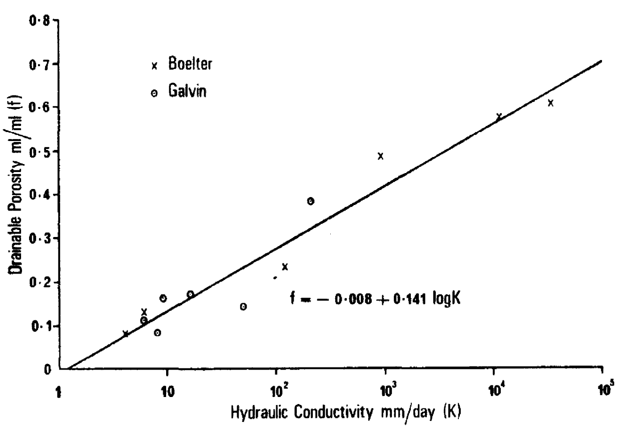


*Fig. 6: Relationship of drainable porosity to hydraulic conductivity for peats*

These results were used in plotting Fig. 7 which shows the variation of strength with MCV for undisturbed and remoulded samples. The curves in Fig. 8 were constructed by combining the results of Fig. 3 and Fig. 7. They show the variation of vane

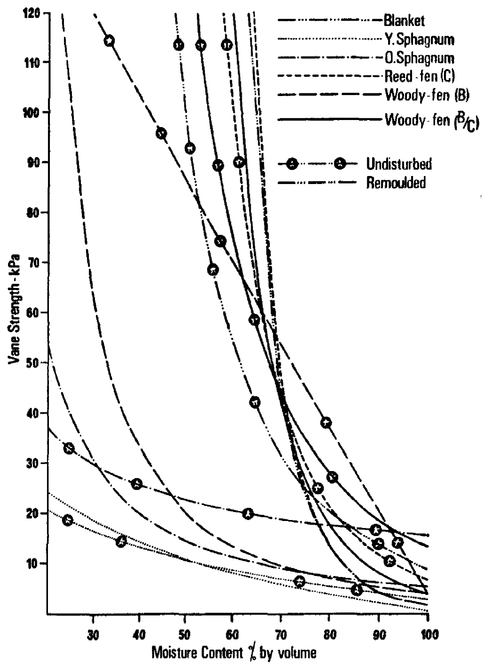


*Fig. 7: Relationship of vane strength to moisture content (% by volume) for Irish peats*

strength with pF for the peats tested and indicate the relative strengths likely to be achieved by these peats under different drainage regimes.

*Consolidation:* One-dimensional consolidation tests were carried out on undisturbed and remoulded samples of all peat types. A single increment of loading was used, which exerted a consolidation pressure of 9.8 kPa (equivalent to pF 2) on the samples. Each test was run for 7 days (10,000 min) and replicated at least 3 times (more often if the individual results showed too great a divergence). The samples were 76 mm diameter × 19 mm thick and were subsampled from 150-mm-diameter undisturbed core samples for the undisturbed tests. For the remoulded tests, samples were taken from initially undisturbed cores which were first remoulded as already described for the strength tests.

Each sample was saturated, carefully trimmed to size, weighed and placed in the consolidation apparatus. The pressure was applied as a single increment and readings were taken in the usual manner for consolidation tests (9). The results were plotted on semi-log paper in the conventional manner and analysed (9) to produce the data in Table 2.

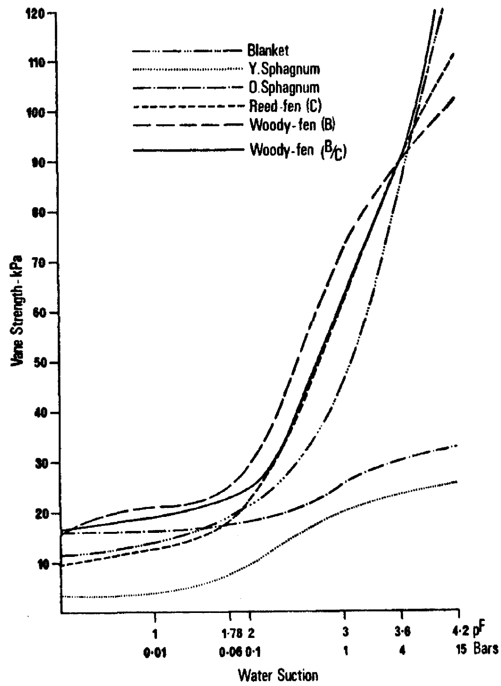


*Fig. 8: Relationship of vane strength to water suction for Irish peats*

## DISCUSSION

The results of a number of analyses are given in Table 1. The degree of humification results show that apart from the relatively undecomposed Younger Sphagnum, which has a value of only H2 on the von Post scale, all other types are moderately to highly decomposed, values ranging from H6 to H8. The natural moisture contents (MCW) show a value for Younger Sphagnum of 1,607 % whereas all the other peat types have values of between 821 % and 1,057 %. However, when these results are converted to MCV values, the figures range from 85.7 % (Reed-fen) to 91.3 % (Younger Sphagnum).

The ash contents fall into two groupings, the fen peats having substantially higher values than the sphagnum and blanket peats. This is a reflection of the base-rich conditions under which the fen peats were formed.

The specific gravity results range from 1.31 to 1.38. Generally, these values are low compared with those for North American and European peats. However, they fall well within the range of values quoted by Hanrahan (10) for Irish peats (1.1 to 1.8) and by Ward (11) for Welsh peats (1.2 to 1.5). If all the peat types had the same specific gravity, a graph relating the void ratio at saturation to the saturation moisture content would give a straight line through the origin with a slope equal to the specific gravity. For the Irish peat types tested, the specific gravity varies within a relatively narrow range (1.31 to 1.38) and an analysis of the measured values of void ratio (at saturation) and MCW (saturated) gave the equation (correlation coefficient=0.989):

$$\text{Void ratio (saturated)} = 0.05 + 0.013436\ \text{MCW}.$$

Void ratio ($e$) figures range from 12.7 to 23.0, the corresponding porosity ($n$) range being 92.7 to 95.8%. These porosity figures are grouped at the top end of the international peat scale and greatly exceed the values (50 to 70%) normally quoted for mineral soils.

The unit weight (natural) and unit weight (dry) results fall within the expected range of values. As already described, regression analyses were carried out on the data accruing from the dry unit weight (bulk density) investigations to produce Figs 1 and 2. The curves in Fig. 1 relate moisture content by weight (MCW) to moisture content by volume (MCV). In Fig. 2 the relationship of bulk density (BD) to MCW is shown. These curves can be used to convert gravimetric moisture contents to MCV values without further measurement of the unit weights for the various peat types involved.

Each hydraulic conductivity result (Table 1) is an average of 20 to 50 measurements. With one exception, a single figure is quoted as a reasonably representative value for each series of tests. In the case of the laboratory measurements on Woody-fen (Type B), however, the full range of results is given as the figures were too scattered, due to the presence of varying amounts of wood, to be averaged. The results showed a reasonable correlation between laboratory and field measurements for the blanket and sphagnum peats. On the Woody-fen peats, however, the field measurements gave far greater values than the corresponding laboratory tests. This variation can be directly related to the presence of woody layers in the peat profile, as laboratory tests on small samples cannot replicate the field conditions obtaining when water is moving through these woody layers.

A series of field measurements is generally the most satisfactory method of obtaining realistic hydraulic conductivity figures. However, the results (Table 1) show that a simple laboratory apparatus (Fig. 3) can give reasonably accurate figures where the peat under test is fairly uniform in texture and free of wood and cracks. But it must be emphasised that a more sophisticated apparatus will give more accurate and more reproducible results.

The infiltration capacity measurements (Table 1) were made above the water-table on areas of bog that were relatively free of wood. The results varied depending on the degree of surface smearing prior to infiltration. Care was taken to minimise this as far as possible and the results shown in Table 1 are, in the case of some of the peats, greater by a factor of 20 than the measurements made before taking special precautions to reduce smearing. Nevertheless, as some of the final results are much lower than corresponding measurements for hydraulic conductivity, all the effects of smearing and possible compaction in preparing the test sites may not have been completely eliminated.

The results of the pF tests are shown in Fig. 4. These curves fall into the expected pattern, the Reed-fen losing the smallest proportion and the Younger Sphagnum the highest proportion of the saturated water content, over the full pF range. For comparison the pF curves of a sandy soil (Screen) and a silty clay loam (Abbeyfeale) are also included in Fig. 4. The results indicate that there should be ample reserves of water in all Irish peats for plant growth. This presupposes that the plants have the ability to seek for and remove the required water from the peat. Some problems have arisen in this field due to the difficulty of incorporating lime to a sufficient depth in the profile. This can result in the failure of the plant root mass to penetrate the water-holding peat layer. Water deficiency symptoms could then become apparent despite the fact that ample reserves of water were available in the peat.

Fig. 5 shows a drying cycle and three re-wetting cycles for Older Sphagnum peat. The curves shown are fairly typical of those obtained for all categories of peat and indicate reasonably good re-wetting characteristics when the peat is subjected to tensions up to pF 3. At the higher tension of 4.2 (wilting point), the water recovery curve is very much flatter, the major portion of irreversible drying presumably taking place when the peat is dried to a moisture content between pF 3 and pF 4.2.

The drainable porosity figures represent the difference between values at saturation and at pF 2 (Table 1). These figures indicate the maximum proportion of water likely to be removed from the peat as the water-table falls, or is artificially lowered by drainage. They can also be used to indicate the likely rise in the water-table level when water (rainfall or irrigation) is added to the peat profile. Results range from 0.08 to 0.38, and can be compared with figures quoted by Boelter (12) for American peats (0.08 to 0.86) and also with figures which Boelter has derived from work carried out by Heikurainen (13) on Finnish peats (0.10 to 0.67). The drainable porosities of Irish and American peats were plotted against the corresponding hydraulic conductivity measurements on semi-log paper and found to lie close to a straight line, when points referring to woody peats are excluded (Fig. 6). A regression analysis on the data gave the equation (correlation coefficient = 0.970):

$$\text{Drainable porosity} = -0.008 + 0.141 \log (\text{hydraulic conductivity}),$$

where hydraulic conductivity is measured in mm per day. Although only six Irish results are used in the calculations, it must be remembered that these are representative results, covering the whole range of Irish peats and that Boelter's results most probably do likewise for American peats. In these circumstances the equation relating drainable porosity to hydraulic conductivity would seem to be well established for a wide range of peats.

The variation of vane strength with MCV is set out in Fig. 7. These curves show that the strength of the remoulded peat was invariably less than that of the undisturbed peat at the higher moisture contents but that the opposite obtained as the peats dried out. An exception to this was Type B (Woody-fen) where the undisturbed

TABLE 2: Consolidation factors measured under a loading of 9.8 k Pa

| | | Primary | | | Secondary |
|---|---|---|---|---|---|
| Peat type | Condition | $\triangle$H/Ho | $a_v$ ($m^2$/kN) | $m_v$ ($m^2$/kN) | Cs |
| Blanket | Undisturbed | .11 | .194 | .012 | .020 |
| Younger Sphagnum | Undisturbed | .20 | .423 | .023 | .018 |
| Older Sphagnum | Undisturbed | .10 | .164 | .011 | .006 |
| Reed-fen (C) | Undisturbed | .09 | .152 | .010 | .008 |
| Woody-fen (B) | Undisturbed | .08 | .121 | .008 | .012 |
| Woody-fen (B/C) | Undisturbed | .11 | .170 | .011 | .012 |
| Blanket | Remoulded | .20 | .321 | .023 | .028 |
| Younger Sphagnum | Remoulded | .26 | .513 | .030 | .023 |
| Older Sphagnum | Remoulded | .26 | .428 | .030 | .022 |
| Reed-fen (C) | Remoulded | .17 | .267 | .019 | .027 |
| Woody-fen (B) | Remoulded | .15 | .213 | .016 | .015 |
| Woody-fen (B/C) | Remoulded | .16 | .239 | .017 | .020 |

$\triangle$H: Primary consolidation
Ho: Initial peat thickness
$a_v$: Coefficient of compressibility
$m_v$: Coefficient of volume compressibility
Cs: Coefficient of secondary compression

peat had a higher strength than the remoulded peat over the range of moisture contents tested. In Fig. 8 the strengths of the undisturbed peats are plotted against the moisture tension (pF) values. These graphs show that, at pF values greater than 2 (assumed field capacity), the strengths of all peats increase as they dry out but that the sphagnums have much slower rates of strength increase than the other peats. The blanket peat shows unexpectedly high strengths. In this case, however, the pF values necessary to give these high strengths would scarcely ever be achieved in practice due to the intrinsically low hydraulic conductivity of blanket peat and to the climatic conditions, particularly in regard to rainfall, under which it normally occurs. In fact, a very intensive system of drains would need to be installed in order to achieve a moisture content approximating to pF 2 and, in many cases, such a system might not be economically feasible. Furthermore, because of the climatic conditions prevailing in parts of the country, even an intensive drainage system may not achieve the desired reduction in moisture content.

The results of consolidation tests on undisturbed and remoulded samples are set out in Table 2. The primary compression of the undisturbed samples of each type of peat was less than that measured in corresponding samples of remoulded peat. Both sphagnum peats had a primary compression of 26% in the remoulded state. However, when tested in the undisturbed condition, the Younger Sphagnum had a value of 20% and the Older Sphagnum only 10%. It would appear that the *in-situ* consolidation of the undisturbed Older Sphagnum was destroyed in the remoulding process. The fen peat results showed primary compressions in the remoulded condition to be approximately double those measured in the undisturbed state, and for all peat types the coefficients of secondary compression (remoulded) were greater than the corresponding undisturbed values.

## ACKNOWLEDGMENTS

The assistance of the following is gratefully acknowledged: P. Maloney for preparing the diagrams and carrying out the laboratory tests at Kinsealy; W. Kelly for his contribution to field work and laboratory testing at Lullymore; T. A. Barry, Bord na Mona, for helpful discussion and assistance in the selection of sampling sites; M. O'Herlihy, B. Corr and J. McNamara for assistance in field and laboratory tests; W. Burke and members of the Soil Physics and Pedology Department for helpful discussion and other assistance; A. J. Cole and staff at Lullymore for assistance and facilities provided; members of the Statistics Department for data processing.

## REFERENCES

1. Barry, T. A., *Proc. 1st Int. Peat Symp., Dublin,* **B. 2**: 3, 1954.
2. Hammond, R. F., Private communication, 1975.
3. Barry, T. A., Carey, M. L. and Hammond, R. F., Soil Survey Bull. No. 30: Bord na Mona and An Foras Talúntais, Dublin, 1973.
4. von Post, L. and Granlund, E., *Arsbok* 19.2. *Sodra Sveriges Torvtilliganger.* 1. *Sveriges Geol. Under-Sokning.* Ser. **C**: 335, 1925.
5. Akroyd, T. N. W., "Laboratory testing in soil engineering." Soil Mechanics Ltd., London, 233, 1957.
6. Boelter, D. H. and Blake, G. R., *Soil Sci. Soc. Amer. Proc.* **28**: 176, 1964.
7. Dowling, P., "The hydraulic conductivity of peats." M.Sc. thesis, Univ. Coll., Dublin, 1969.
8. Hanrahan, E. T., *Trans. I.C.E.I.,* **92**: 32, 1965/66.
9. Capper, P. L. and Fisher Cassie, W., "The mechanics of engineering soils." Spon. London, 315, 1960.
10. Hanrahan, E. T., *Geotechnique* **4**: 108, 1954.
11. Ward, W. H., *Proc. 2nd Int. Conf. on soil mech. and foundation engng* **2**: 19, 1948.
12. Boelter, D. H., *Int. Symp. on the hydrology of marsh-ridden areas, Minsk,* **1**: 1972.
13. Heikurainen, L., *Acta for. Fenn.* **76**: 5, 1963.

*Received November 21, 1975*